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WEATHER BUREAU

WASHINGTON, D. C.

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Correction.—Schroeppel, Hastings, and West Monroe, listed as counties on page 266, July 1934 Monthly Weather Review, are localities in Oswego County, N. Y. The total damage from this storm in Oswego County should be "$500,000", not "$575,000".

MONTHLY WEATHER REVIEW

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TURBIDITIES OF AMERICAN AIR MASSES AND CONCLUSIONS REGARDING THE SEASONAL VARIATION IN ATMOSPHERIC DUST CONTENT

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This paper deals with a statistical study of atmospheric turbidity for Lincoln, Nebr., Madison, Wis., Washington, D. C., and Blue Hill, Milton, Mass. Means for various air masses are presented, together with several situations showing changes in turbidity of the same air mass as it passes each station. Also conclusions are offered regarding an autumn-winter-spring variation in atmospheric dust content.

The Linke turbidity factor T is defined by Linke (**6**) as the ratio of the atmospheric extinction coefficient to the molecular extinction coefficient.[1] Since atmospheric depletion of solar radiation is due not only to molecular scattering but also to dust scattering and absorption by water vapor, the Linke factor is always greater than unity. It is defined mathematically as

$$T=\frac{1}{a_m m}\log_e\frac{I_o}{I}=P(m)\log_{10}\frac{I_o}{I},$$

where I_o is the solar constant corrected to actual solar distance; I is the total intensity of the direct solar radiation; m is the optical air mass computed from the solar altitude; and a_m is the molecular scattering coefficient and is a function of m.

Hence, by observing I and m, T may be easily computed. The function $P(m)$ has been computed by Feussner and Dubois (**2**) and is tabulated on page 23 of the monograph by Haurwitz (**4**).

The normal intensities of solar radiation for Lincoln, Madison, and Washington were taken directly from the observations published in the MONTHLY WEATHER REVIEW and cover the period from January 1931 to May 1933, excluding the months June, July, August, and September because of lack of analyzed maps. The published values are for integral values of m only and are derived by the observer from interpolation and extrapolation of the original intensities. For Blue Hill the original observations (not the values for integral optical air mass published in the MONTHLY WEATHER REVIEW) were used; the period covered is from December 1932, immediately after the solar radiation program at Blue Hill was begun, to May 1933. The synoptic air masses present at the various stations were identified from the synoptic charts analyzed by the Meteorological Division of Massachusetts Institute of Technology.

Since local conditions of smoke, dust, haze, and clouds may influence turbidity, a detailed description of the exposures of the various instruments is necessary. At Washington, Lincoln, and Madison, the Marvin type pyrheliometer is used; a description of the exposures at these stations is quoted in part from Kimball (**5**) p. 26:

> At Washington [38°56′ N., 77°05′ W., 397 feet mean sea level] the measurements are made on the campus of the American University about 5½ miles northwest of the United States Capitol. There are no manufacturing establishments within a radius of about 3 miles, but the suburb about the university is rapidly building up, principally with detached houses. The pyrheliometer is exposed on a shelf outside a window, in the morning on the southeast side of the building and in the afternoon on the southwest side. At times, with southeast or east winds, city smoke is brought over the university.
>
> At Madison [43°05′ N., 89°23′ W., 974 feet mean sea level] the pyrheliometer is installed in North Hall, University of Wisconsin, and exposed on a shelf outside a window facing east in the morning and west in the afternoon. North Hall is on a bluff in the upper campus, a short distance from the south shore of Lake Mendota. Most of the manufacturing plants are in the eastern part of the city, but railroad tracks and the heating plant of the university are to the southwest. With a northwest wind the air is free from smoke, but with the wind from other directions considerable smoke is brought over the campus.
>
> At Lincoln [40°50′ N., 96°41′ W., 1,225 feet mean sea level] the pyrheliometer is exposed in the experiment-station building, on the farm campus, State university farm. It is 2½ miles northeast of the center of the business section of the city, but there is some smoke from buildings on the farm campus and from railroads and shops not far to the north. Under certain conditions the city smoke cloud covers the farm campus, but with a west to northwest wind the atmosphere is very clear. When observing the pyrheliometer is exposed on a shelf outside a south dormer window.

At Blue Hill [42°13′N, 71°05′ W, 640 feet mean sea level], the pyrheliometer is of the Smithsonian silver-disc type and is exposed on the tower of the observatory, 672 feet above sea level and about 400 feet above the surrounding countryside. The area of maximum smoke production is at Boston, about 6 to 12 miles away, and subtends an angle from about NNE. to NW. Minor smoke sources are located to the northwest in the suburbs of Boston, to the southwest at the small town of Canton, 4 miles distant, and to the southeast in Brockton, a city of about 50,000 population, 10 miles away. Providence and Fall River, large factory cities, are 30 to 40 miles SW. to S. The surrounding countryside is mostly forest and meadow. The Atlantic Ocean subtends an angle from NE. to about SSW. and varies in distance from about 10 miles to the northeast and east to about 60 miles to the south.

In order to obtain turbidity factors which are representative of the prevailing air mass type, observations which are affected by local conditions of clouds, smoke, fog, dust, etc., must be eliminated. For Madison, corrections from January to October, 1931, could be made only by consulting the 7 a.m. and 7 p.m. reports at La Crosse, 100 miles to the northwest. The hourly observations of wind, sky, clouds, visibility and ceiling taken at

[1] T may be also defined approximately as the number of clean, dry atmospheres which would diminish the direct solar intensity by the same amount as does the single, moist, dirty atmosphere.

the newly established airways station from October 1931 to March 1933 were consulted.[2] For Lincoln, the 7 a.m. and 7 p.m. observations at Omaha, 50 miles to the northeast were used until October 1931 after which time observations of wind, cloud, and sometimes visibility were available from Lincoln itself. For Washington, the 8 a.m. and 8 p.m. reports on the weather maps were taken. At Blue Hill, observations of sky, cloud, wind and visibility, which were taken simultaneously with the solar observations, permitted a careful check on the local conditions.

It is desirable at this point to examine briefly whether the Linke factor satisfies two of the fundamental properties that a true turbidity measure should have:

(1) *Uniqueness:* that is, to a given optical state of the atmosphere there must correspond a constant measure of turbidity which shall be independent of the solar altitude and thus measurable at any time during the day. Feussner and Dubois (**2**) publish the following table, showing the virtual range of the Linke factor with optical air mass for a clean moist atmosphere of varying amounts of precipitable water.

TABLE 1.—*The virtual range of the Linke factor with optical air mass (m) for a clean moist atmosphere for varying amounts of precipitable water (w)*

w \ m	1	2	3	4	6	8	10	15
0.5 cm	1.71	1.64	1.67	1.65	1.64	1.66	1.66	1.72
1 cm	2.22	2.03	1.98	1.95	1.93	1.94	1.95	2.04
3 cm	3.33	2.92	2.81	2.77	2.83			

From this it appears that T (for small values of m) decreases with increasing m and increases with increasing w. The percent change in T is greatest for an increase in m from 1 to 2, and is equal to about 4 percent for w=0.5 cm and 12 percent for w=3.0 cm. When m increases from 2 to 3, the change is smaller, being less than 2 percent for w=0.5 cm and less than 4 percent for w=3.0 cm. For further increases in m the differences become even smaller. Now the majority of solar observations published in the MONTHLY WEATHER REVIEW correspond to the optical air masses 2, 3, and 4, and, as shown in table 1, the virtual range for these air masses is small, amounting to less than 4 percent for 3 cm of precipitable water—a high water content of the atmosphere on days suitable for solar observations during the nonsummer months. For Blue Hill, most of the observations are taken within air masses 2 to 4 except for those taken in the spring and early autumn, when the majority of observations are closely grouped around some value of $m<2$, because then the high altitude of the sun causes an air mass of less than 2 to prevail for several hours before and after local noon. Hence, the virtual range of T in a clean, moist atmosphere is within 4 percent for the majority of observations. Concerning the effect of dust on the range of T nothing seems to be known. An example of the scattering of values of T in a synoptic air mass whose optical state is more or less constant, is shown in table 2, observations taken at Blue Hill on February 9, 1933, a day on which a deep current of Polar Continental air was passing over the station and the ground was covered with snow.

The irregular fluctuations in T are probably due to observational errors. The increase of T with m in the afternoon probably follows the wind shift to a more southerly quarter accompanied by an increase in water vapor and perhaps in dust content as shown by the increased cloudiness and decreased visibility.

[2] However, for April and May, 1933, the regular morning and evening observations at Madison were used.

TABLE 2.—*Atmospheric turbidity at Blue Hill, Mass., during Feb. 9, 1933*

m	T	Sky conditions	Wind
3.57	1.85		
3.45	1.78	Few Frcu.	
3.34	1.78	Visibility 9	WNW. 17 m.s.
3.03	1.69	Horizons clear	
2.95	1.73		
2.88	1.68		
2.74	1.69		
2.68	1.72	Few Cu and Frcu.	WNW. 19
2.62	1.71		
2.51	1.88		
2.48	1.83		
2.44	1.85		
2.08	1.87		
2.06	1.96	Few Cu and Frcu.	
2.03	1.83	Visibility 10	WNW. 15.
1.97	1.95		
1.95	1.92		
1.94	1.85		
1.89	1.98		
1.88	2.19	Few Cu and Frcu.	
1.87	1.97	Visibility 10	WNW. 15.
1.83	1.77		
1.83	2.09		W. 15.
2.42	2.21		WSW. 10.
2.44	2.13		
2.72	2.12	2/10 Cu and Frcu.	WSW. 9.
2.79	2.10	Visibility 8.	
2.86	2.10		
Mean	1.90		

(2) *Reduction of T to Standard Level:* For purposes of comparison, it is important that the turbidities observed at stations of different elevation be reduced to a standard level. Feussner and Dubois (**2**) give a formula for reducing turbidity values to the 760 mm *Hg* surface by assuming that the dust and water content of the air column above the standard level is exactly the same as that above the level of the observing station. In this case, then, the correction is negative; for Lincoln, Nebr., the highest of our stations, the correction is −0.02 for turbidities between 1.42 and 1.62 and −0.14 for turbidities between 3.93 and 4.34. Corrections for elevation were made for Lincoln, Madison, and Blue Hill, but for Washington they were omitted, being practically negligible at such a low elevation.

The designations of the synoptic air masses introduced into this country by the Meteorological Division of the Massachusetts Institute of Technology are followed here. Although Willett (**8**) has described the characteristic properties of these various air masses in detail, it is desirable to include here a brief description of them. *Polar Continental Air* (*Pc*) acquires its properties over northern Canada and Alaska; besides being dry and cold, it is relatively free from dust. *Modified Polar Continental Air* (*Npc*) is air of polar continental origin which to some extent has lost its original coldness and dryness in the lower layers, and is usually characterized by marked inversions, probably due to subsidence, above which the accumulated pollution and moisture cannot rise. *Modified Polar Pacific Air* (*Npp*) is of polar origin, warmed and moistened in its lower layers by passage over the northern Pacific Ocean, but which has lost most of its moisture and acquired dust, smoke, etc. before reaching the eastern United States. *Tropical Maritime Air* (*Tm*) originates over the Gulf of Mexico or the adjacent portion of the Atlantic Ocean, and is characterized by warmth and high moisture content in the lower layers. *Tropical Continental Air* (*Tc*) is air from the hot, dry, southwestern portion of the United States and Northern Mexico and has low moisture content but a high dust content.

Pyrheliometric observations taken in the neighborhood of a front, where 2 types of air mass may have been present, 1 on the surface, the other aloft, were eliminated. In determining the turbidities characteristic of the different types of air, and the changes in these tur-

bidities as the air mass moves across the country, no attempt was made to note the change in turbidity of an individual air column because of lack of an adequate number of solar stations and the difficulty of determining the true trajectory from only twice daily reports. The air over Lincoln and Madison in general has traveled over cleaner regions than that over Blue Hill or Washington. Hence, when we speak of "the change in turbidity of an air mass moving across the country" we refer to the change in turbidity brought about by differences in the trajectories of the air streams. However, the change in turbidity of a single air column may be approximated in the case of an anticyclone which, after moving eastward, becomes stationary for several days; such a situation, that of October 15–22, 1931, is discussed later.

The mean turbidities for the various stations and synoptic air masses are given in table 3. The observations for Lincoln, Madison, and Washington cover the period from January 1931 to May 1933, omitting the months June, July, August, and September, because of lack of maps analyzed by the Massachusetts Institute of Technology for this period during 1931 and 1932. The subscripts attached to the turbidities refer to the number of days of observation. Days on which observations were widely scattered or less than two in number were eliminated.

TABLE 3.—*Mean turbidities of synoptic air masses*

	Lincoln, Nebr.	Madison, Wis.	Blue Hill, Mass.	Washington, D. C.
Pc	1.87_{23}	2.09_{30}	2.08_{18}	2.54_{28}
Npp	2.34_{88}	2.35_{44}	2.55_{19}	2.62_{42}
Npc	2.46_{28}	2.55_{35}	2.76_{23}	2.80_{24}
Tm	3.39_3			3.32_6
Tc	3.69_3	3.53_6		3.70_7

The values in table 3 show that at all four stations Pc air has the lowest turbidity and is followed by Npp air;[3] Npc air ranks third, and is followed by Tm and Tc air, although the number of observations within the tropical air is small. This result is in agreement with our knowledge concerning the source regions and vertical structure of the air masses. Pc air, originating over comparatively clean and dry regions and moving swiftly to lower latitudes should be expected to have the lowest turbidity factors. However, as the Pc mass begins to stagnate in the form of an anticyclonic circulation centered over the Middle Eastern States, as is often the case, and is transformed into Npc, the increasingly marked inversions which are thought to be due to subsidence (**8**, p. 19 ff.) keep the acquired pollution concentrated in the surface layers. In this case the turbidity increases until it is higher than that of Npp, wherein the usually steeper lapse rate allows the acquired pollution to be carried upward and thence removed by the winds aloft.[4] The high turbidity of the Tm air is probably due to the large amount of water vapor in its lower layers, and that of the Tc air to its large dust content.

The increase in turbidity as the air masses move across the country is shown for the three common types of air. The increase is most pronounced for Pc air, ranging from 1.87 at Lincoln to 2.54 at Washington, although it is possible that the Washington value is increased by the inclusion of cases of Pc air which might just as well have been called Npc, since in many cases the time of transition from Pc to Npc is quite arbitrary. Npc and Npp air show a smaller increase in turbidity from Lincoln to the east coast. The difference in turbidity between Pc and Npc air at Lincoln and Madison, two stations not far from the Pc source region, might tempt one to ascribe it to local conditions were it not for the rather surprising constancy of the Npp turbidity at the two stations.

In table 4, the turbidities for the stations have been arranged according to seasons: Winter, including December, January, and February; spring, including March, April, and May; and autumn, the months October and November. The mean values, weighted according to the number of days of observations, are given for the individual years and also for the entire period. The values for Blue Hill for the fall of 1933 (including also September) are included in this table.

TABLE 4.—*Mean atmospheric turbidities by air masses, by seasons, by years*

Air	1931			1932		
	Lincoln	Madison	Washington	Lincoln	Madison	Washington
Pc	1.90_1	1.85_1	2.64_5	1.77_5	2.00_3	2.45_2
Npp	2.28_{14}	2.51_9	2.41_5	2.18_{10}	2.17_5	2.43_6
Npc				2.10_{18}	2.09_8	2.42_4
Tm						
Pc	1.77_1	1.94_2	2.64_3	1.89_5	2.03_2	2.69_3
Npp	2.69_{13}	2.85_3	2.73_2	2.53_7	2.65_4	2.65_4
Npc	2.86_3	2.76_{11}	3.02_1	2.94_2	2.68_3	2.95_{11}
Tm						3.46_3
Tc	4.28_1	3.60_3	3.71_7	3.33_3	3.16_1	
Pc				1.69_1	1.97_6	2.49_3
Npp	2.29_{17}	2.19_{13}	2.27_8	2.14_8	2.38_4	2.25_8
Npc		2.40_1	3.24_2	2.42_2	2.34_2	2.78_4
Tm			2.96_2			

Air	1933				Total				Season
	Lincoln	Madison	Washington	Blue Hill	Lincoln	Madison	Washington	Blue Hill	
Pc	1.87_7	1.95_7	2.20_4	1.91_8	1.82_{13}	1.95_{11}	2.45_{11}	1.91_8	
Npp	2.13_{13}	2.33_6	2.70_8	2.52_{13}	2.20_{27}	2.37_{20}	2.52_{17}	2.52_{13}	
Npc	2.25_2		2.57_5	2.66_5	2.13_{12}	2.09_8	2.53_{11}	2.66_5	Winter.[1]
Tm			3.61_1				3.61_1		
Pc	2.26_5	2.16_7	2.48_4	2.21_{10}	2.05_{11}	2.10_{11}	2.59_{10}	2.21_{10}	
Npp	2.53_8	3.50_1	3.47_7	2.73_2	2.60_{28}	2.83_8	3.10_{13}	2.73_2	Spring.
Npc	2.56_5	2.78_7	2.93_4	2.80_{17}	2.73_{10}	2.75_{24}	2.95_{16}	2.80_{17}	
Tm	3.39_3				3.39_3		3.46_3		
Tc					3.57_4	3.53_6	3.71_7		
Pc				$(2.02_{16})^2$	1.69_1	1.97_6	2.49_3	$(2.02_{16})^2$	
Npp				(2.52_8)	2.24_{35}	2.24_{16}	2.26_{11}	(2.52_8)	
Npc				(2.61_8)	2.42_2	2.36_3	2.93_4	(2.61_8)	Autumn.[3]
Tm							2.96_2		

[1] December 1930 omitted.
[2] September 1933 included.
[3] September omitted for all years.

The four stations show clearly a seasonal trend in T for all principal types of air. Comparing the winter with autumn values in the last column we see that there exists no clean-cut distinction between the two seasons. The Pc air masses seem to be slightly cleaner in winter than in fall; for Npc air the difference is greater except at Blue Hill whose autumn value is slightly less than the winter value. In the Npp air the turbidity for Madison and Washington is lower in the autumn, while at Blue Hill the turbidity remains the same, and at

[3] This result modifies that found for Washington in a preliminary study made by the author (7) covering the period January 1931 to December 1932. In this study Npp air, on the basis of 31 days' observations was found to be the cleanest, T=2.44, and Pc, on the basis of 18 days' observations, the next cleanest, T=2.64.

[4] This reason is open to doubt, for it might well be that, due to horizontal advection of dust by winds aloft, the net loss of the dust content of an air column is zero. To examine more closely the relative turbidities of Npc and Npp air, the average water contents of both types of air were computed from the Massachusetts Institute of Technology airplane soundings for the year 1933, excluding June, July, August, and September, when no soundings were made. For Npp air, from 12 days' observations, the mean precipitable water content was 11.1 mm; while 25 days of Npc air showed 11.8 mm. Hence, we may assume that the water content of the two types of air is the same. If we also assume that the smoke and dust production within the two air masses is the same, then it follows from the higher turbidities in the Npc air that the concentration of a given amount of dust and water vapor in a thin surface layer causes greater depletion of direct solar radiation than if the dust and vapor had been distributed throughout a thicker layer. This phenomenon may perhaps be explained in the following manner: The reflection of light from a sharp smoke and dust line in the atmosphere (such as occurs very often in the Npc air masses) is greater than the reflection and scattering from the smoke and dust particles in a thicker layer lacking a distinct top (as in Npp air) due to the fact that in the latter case secondary reflection and scattering by the particles is brought into play and so enables more sunlight to pass through the layer.

Lincoln it is slightly larger in the autumn. It is when we compare spring-autumn values that the contrast is striking. For all stations and air masses, each year shows a larger turbidity in the spring than in the autumn. In order to investigate the reason for this difference, I have gathered some aerological data showing the seasonal trend of the water content of the atmosphere for the regions considered.

Since the Linke factor does not distinguish between depletion of solar radiation due, on one hand, to absorption by water vapor and, on the other hand, to scattering by small particles in the atmosphere, we may try to get a measure of the latter effect for winter, spring, and autumn by assuming values of the atmospheric water content for these seasons which are in agreement with some available aerological material. In other words, we may try to obtain measures of atmospheric dust content for winter, spring, and autumn. This is one of the aims of the turbidity coefficient defined by Ångström (1, 1930). This turbidity coefficient, β, is claimed to be proportional to the dust content of a column of air and is obtained by measuring the depletion of solar radiation in a spectral band where absorption by water vapor is negligible. However, in order to obtain the Ångström coefficient a recording thermopile and special glass filters are necessary. This apparatus is available in this country only at Washington and Blue Hill. Hence, in order to obtain seasonal comparisons in atmospheric dust content from the observations taken at the two midwestern stations, Lincoln and Madison, values of atmospheric water content must be obtained from another source; namely, the aerological material.

Gregg (3) has published data giving the vertical distribution of atmospheric and vapor pressure by months over Mount Weather, Va., and the seasonal means of these elements from aerological observations at Omaha, Nebr., Indianapolis, Ind., Huron, S. Dak., and Avalon, Calif. The observations from Mount Weather were obtained from kite ascensions and are given in monthly means of atmospheric pressure (based on 3 years' observations) and of vapor pressure (based on 1 year's observations); the vapor pressure means, however, are given only to 3 kilometers because of scarcity of observations at higher levels. The western group of observations are seasonal means computed from sounding balloon ascents, the data from which were used up to and including the 7-kilometer level. In addition to the above-mentioned material, I have computed for Dr. H. H. Kimball, in connection with his determinations of atmospheric water content from filter measurements of solar radiation (published in the September 1934 MONTHLY WEATHER REVIEW), a series of comparable atmospheric water contents as determined from the Massachusetts Institute of Technology airplane soundings at the East Boston Airport, which averaged to about 5,000 meters in height. Since these evaluations were made only for the days on which solar observations were possible, they are rather few; but, nevertheless, are therefore more truly representative of the days considered in this paper.

The precipitable water content is defined as the depth of liquid water which would result if all the water in a vertical column through the atmosphere of cross-sectional area 1 square centimeter, were condensed. It is given by the formula

$$N=-6.344\int_{p_0}^{p_1}\frac{e}{p}\mathrm{dp}=-14.60\int_{p_0}^{p_1}e\cdot d\log_{10}p,$$

where N is the depth of precipitable water in millimeters; e is the vapor pressure in mb.; p is the atmospheric pressure; and p_0, p_1 are the pressures at the top and bottom of the air column.

N was found by numerical integration of the data, where vapor pressure means were taken between their respective atmospheric pressure levels, and multiplied into the log of the respective pressure differences and summed up for the air column. The results for the three groups of observations are given in table 5.

TABLE 5.—*Mean precipitable water, by seasons*

	Winter	Spring	Autumn
	Millimeters	*Millimeters*	*Millimeters*
Mount Weather, Va.	7.2	13.9	[1] 14.0
Western group	7.9	20.3	24.2
East Boston, Mass.	7.4_{13}	9.2_{22}	[1] 13.0_{31}

[1] September omitted.

As expected, the water contents are higher for spring and autumn than for winter. Also the values are considerably higher for autumn than for spring except for Mount Weather. However, the autumn mean for this station is probably too low since it is based on a single year's vapor pressure observations, which includes a dry November, whose water content was 8.1 mm as compared with 19.9 mm in October and 10.6 mm in December for the same station and 10 mm on the basis of 15 days' November observations at East Boston (1933). The Boston values are lower than those of the other groups, probably because they represent only the days when condensation forms did not prevent solar observations.

Hence, we see that although more water vapor seems to be present in the atmosphere in autumn than in the spring, the turbidities are higher in the spring. This must mean that there is more dust and smoke present in the atmosphere over the four stations in the spring than in the autumn. This conclusion is strengthened in the cases of Washington and Blue Hill by the measurements of the Ångström turbidity coefficient, β. For Washington I have computed the seasonal means from two sources—The first from the values published by Ångström (1) which covered the period 1903–7 and were determined from measurements by the Astrophysical Observatory of the Smithsonian Institution.

Ångström used the intensities at wave lengths 0.45μ and 0.90μ to determine from two simultaneous equations β, the turbidity coefficient, and α, the size coefficient, which varies from 4 for molecules to 0 for large particles, scattering nonselectively. From these computations, α was found to be 1.24, corresponding to scattering particles of mean diameter slightly larger than 1μ. The second source is the values of β for 1932 presented in the MONTHLY WEATHER REVIEW, determined from measurements made under the assumption that $\alpha=1.3$. For Blue Hill, the β's determined during 1933, under the same assumption regarding constancy of α, were employed. The seasonal means of the β's are presented in table 6.

TABLE 6.—*Ångström turbidity coefficients, means by seasons*

	Winter	Spring	Autumn
Washington, 1903–07	0.063	0.136	0.056
Washington, 1932	[1] $.079_{11}$	$.099_{29}$	[2] $.056_{12}$
Blue Hill, 1933	$.062_{14}$	$.064_{22}$	$.055_{28}$

[1] January omitted as observation began in February.
[2] September omitted.

The above values show that the β's are higher in spring than in autumn for the three sets of observations; this agrees with the conclusions derived from the Linke factor data for Washington and Blue Hill, showing greater dust content in the spring than in the autumn. Therefore, it is justifiable to make similar conclusions regarding a spring-autumn contrast in dust and smoke for Lincoln and Madison, where equipment for measuring the β's is not available.

A surprising feature of table 6 is the presence of larger β's for the three sets of observations in the winter than in the autumn. The winter-autumn Linke factors in table 4 for Washington and Blue Hill showed no such distinct contrast. However, assuming the Linke factors to be slightly lower in winter than in autumn, and noting from table 5 that the atmospheric water contents for the two stations in the autumn are twice those in the winter, we are led to the conclusion that there exists more dust and smoke (smoke probably predominating) in the atmosphere over Washington and Blue Hill in the winter than in the autumn. This conclusion is derived only from considerations of the Linke factors in conjunction with the aerological data. The Ångström coefficients presented in table 6, however, which are derived from an entirely separate set of observations, are in agreement with the above conclusion, and, therefore, we feel justified in saying that over Lincoln and Madison more dust and smoke seems to be present in the winter than in the autumn.

Thus far we have concluded that there is present more dust and smoke in spring and also in winter than in the autumn.[1] For Blue Hill and Washington, we arrived at these conclusions from two sets of data: first, the Linke factors in conjunction with aerological data; and, second, the Ångström coefficients. Inasmuch as we found that the conclusions derived from the first set of data were supported by the second set of data, we felt justified in extending these conclusions to Lincoln and Madison, where means for measuring the Ångström coefficients are lacking. In contrast to the Ångström coefficients the conclusions derived from the first set of data were qualitative; if quantitative results were desired, then definite assumptions as to mean water contents for the various seasons would have to be made. This procedure would be safe only at Blue Hill, where water contents were determined for about two-thirds of the days on which the Linke factors were observed. Now, in seeking a winter-spring contrast in dust and smoke content, it is impossible to derive conclusions qualitatively, since both the Linke factors and water contents are higher in spring than in winter, as shown in tables 6 and 4. In this case, then, quantitative methods must be applied. From table 6, the water contents over East Boston for winter and spring are 7.4 mm and 9.2 mm, respectively. From the values given in table 2, we find that an atmosphere containing 5 mm of precipitable water has for its Linke factor 1.65, approximately, and for an atmosphere containing 10 mm precipitable water, T=2, approximately. From linear interpolation, we find that w=7.4 mm corresponds to T=1.81, and w=9.2 mm corresponds to T=1.94. The mean of the observed T's for winter and spring weighted according to the number of days of observations, were found from table 4 and results of the computation are given in table 7.

[1] This is in accord with the determination of the dust content of the surface air at Washington in 1922–25, MO. WEA. REV., vol. 53, p. 243, table 1.

TABLE 7.—*Winter vs. spring dust turbidities at Blue Hill, 1933*

	w	T_w	$T_{obs.}$	$T_d=T_{obs.}-T_w$
	mm			
Winter	7.2	1.81	2.36_{22}	0.55
Spring	9.4	1.94	2.59_{22}	.65

Hence, for Blue Hill, 1933, more dust and smoke was present in the spring than in the winter in the ratio, 0.65/0.55=1.18. Also, from the β's given in table 6, more dust and smoke is indicated for the spring in the ratio 0.064/0.062=1.03. The discrepancy between the two ratios may be due to the fact that the β's were found from 46 days' observations, whereas the T's were found from 55 days' observations.

CHANGES OF TURBIDITY WITHIN AN AIR MASS

Three situations wherein observations were taken within the same air mass are presented below:

1. *Situation of January 22–24, 1933.*—Npp advanced east and northeastward behind a LOW which followed a path from Lake Michigan, on the 22d, to the mouth of the St. Lawrence River, on the 23d. The air mass reached Lincoln on the 22d, Madison on the 23d, Blue Hill on the 24th, and finally, Washington on the 24th. Blue Hill during most of the 23d was in a frontal zone between Npp and Tm. The turbidities are presented in table 8; the subscripts attached to the T's refer to the number of individual observations made on the day in question.

TABLE 8.—*Turbidities in an advancing Npp air mass, Jan. 22–24, 1933*

Lincoln	Madison	Blue Hill	Washington
Jan. 22, $T=1.88_1$	Jan. 23, $T=1.92_3$	Jan. 23, $T=2.50_5$ Jan. 24, $T=2.03_7$	Jan. 24, $T=2.59_7$

The increase in T from 1.88 at Lincoln to 2.59 at Washington is undoubtedly due to the different trajectories of the air columns present over each station. For Lincoln, Madison, and Blue Hill the trajectories were over relatively clean regions, since the winds at the time of observation were mostly from the west and northwest. For Washington the trajectory lay over the industrial part of the country; hence, considerable pollution principally in the form of smoke was acquired. At Blue Hill, the effect of Tm aloft is shown on the 23d, when T=2.50; on the next day, however, when Blue Hill was well within the Npp current, T dropped to 2.03.

2. *Situation of December 14–16, 1931.*—On the 14th, a Npc air mass covered the United States from the Rockies to the Mississippi River and spread eastwards to Washington before 8 p. m. the same day. On the 15th the mass split into two anticyclonic centers, one over the East and the other over the Rockies, so that Lincoln on the 16th was in a region of convergence between the two HIGHS and had at the surface a thin layer of fresh Npc air coming from the northwest, and at upper levels the older Npc air coming from the south. The values of T are given in table 9.

TABLE 9.—*Turbidities in an advancing Npc air mass, Dec. 14–16, 1931*

Lincoln	Madison	Washington
Dec. 14, T=1.96$_8$ Dec. 15, T=2.13$_6$ Dec. 16, T=2.22$_5$	Dec. 14, T=1.94$_2$	Dec. 15, T=2.42$_4$

The increase in T from 1.96 in the Midwest to 2.42 in Washington on the following day shows the rapid pollution of the Npc air as it travels eastward. Because of the subsidence inversion which is thought to exist in the Npc air, this acquired pollution is probably concentrated in a thin surface layer. At Lincoln the successive increases in T on the 14th, 15th, and 16th show how the turbidity is increased when the direct flow of Npc from the northwest is replaced by a flow from southerly quarters due to movement of the high pressure center eastward.

3. *Situation of October 16–21, 1931.*—A large body of Npp air covered a major portion of the continent on the 15th; on the night of the 15th–16th it invaded Madison, and on the morning of the 17th, Washington. The air mass stagnated, the anticyclonic center remaining over West Virginia from the 17th to the 21st. On the night of the 21st–22d, fresher Npp reached Washington. The values of T are given in table 10.

TABLE 10.—*Turbidities in an advancing Npp air mass, Oct. 16–21, 1931*

Lincoln	Madison	Washington
Oct. 15, T=2.03$_2$ 16, 1.98$_1$ 17, 2.13$_8$ 18, 2.45$_4$ 19, 2.33$_4$	Oct. 16, T=2.27$_4$ 17, 1.87$_3$ 19, 1.84$_1$ 20, 3.49$_4$	Oct. 17, T=2.14$_4$ 19, 2.43$_8$ 20, 2.24$_8$ 22, 2.12$_3$

The Lincoln T's show a gradual increase from about 2 on the 15th-16th, to about 2.4 on the 18th-19th, corresponding to the shifting of the wind on the 17th from the northwest, which brought in fresh Npp, to the south, bringing in older Npp. The high turbidity at Madison on the 16th may be explained by local conditions since the morning observer reports smoke and a visibility of 8 miles with a northwest wind. The wind shifted into the south on the 19th and the older return air on the 20th shows a much larger value, T=3.49; here, again, the observer reports smoke and a visibility of 8 miles with a south wind. The turbidity at Washington increases from 2.14 on the 17th, when the fresh Npp current came in, to 2.43 an the 19th, after the high had stagnated. The drop in T to 2.24 on the 20th, when conditions were practically unchanged cannot be explained from the available data. However, the decrease to 2.12 on the 22d is probably due to fresh Npp displacing the older Npp.

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BIBLIOGRAPHY

(1) Ångström, A., Atmospheric transmission of sun radiation and dust in the air. Geografiska Annaler, 1929, Bd. 11.
——— Atmospheric transmission of sun radiation, Pt. II, Ibid, 1930, Bd. 12.
(2) Feussner, K., and Dubois, P., Trübungsfaktor, precipitable water, Staub. Gerl. Beitr. z. Geophysik, 1930, Bd. 27.
(3) Gregg, W. R., Mean values of free-air barometric and vapor pressures, temperatures, and densities over the United States. MO. WEA. REV., 1918, v. 46, pp. 11–20.
(4) Haurwitz, B., Daytime radiation at Blue Hill Observatory in 1933 with application to turbidity in American air masses. Harvard Meteorological Studies, no. 1, 1934.
(5) Kimball, H. H., Solar radiation measurements. MO. WEA. REV., 1932, v. 60, pp. 26–27.
(6) Linke, F., Transmissionskoeffizient und Trübungsfaktor. Beitr. z. Phys. d. fr. Atmos., 1922, Bd. 10.
(7) Wexler, H., A comparison of the Linke and Ångström measures of atmospheric turbidity and their application to North American air masses. Trans. Amer. Geophys. Union, 14th Annual Meeting, April, 1933, Washington, pp. 91–99.
(8) Willett, H. C., American Air Mass Properties. Papers in Physical Oceanography and Meteorology, Mass. Inst. of Techn. and Woods Hole Ocean. Inst., 1933.

SOME WIND VELOCITY CORRELATIONS

ERIC R. MILLER

[Weather Bureau, Madison, Wis., Dec. 1934

Two studies of wind velocity in as many relationships, employing the methods of correlation analysis, are reported in this paper:

1. *True versus indicated velocity.*—Among the assets of the meteorologist that a banker would classify as "slow" rather than frozen, are the data of wind velocity that were written down in the records before the reduction to true velocity commenced January 1, 1932. The precise relation between true velocity and indicated has been set forth in the papers by Marvin entitled "A Rational Theory of the Cup Anemometer" (MONTHLY WEATHER REVIEW, **60,** 1932, pp. 43–57) and "Recent Advances in Anemometry" (MONTHLY WEATHER REVIEW, **62,** 1934, pp. 115–120), where the lines that represent the functional relation show a pronounced curvature near the origin. In the present study, the observed results flow from the official conversion table in Instructions No. 14, 1931.

It is obvious that the conversion table just mentioned cannot be applied to monthly averages, inasmuch as the latter comprise a wide spectrum of different velocities, each requiring a different correction. The object of this study is to discover the law of relationship of the monthly means of the indicated velocities to the means of the true velocities.

In preparing this paper the hourly wind movement for each of the 236,320 hours in the 27 years, 1905–31, was converted to true velocity by applying the official correction. The results were averaged and compared with the averages of the raw data. The help of eight students in the University of Wisconsin who made the conversions and averages, and of Messrs. Batz and Lorenz of the staff of the Madison Weather Bureau Office in checking the arithmetic, is gratefully acknowledged.

In the case of the three-cup anemometer, the official conversion table adds 1 mile to all indicated velocities from 0 to 16, no correction to 26, and subtracts about 12.5 percent from higher indicated velocities. The averages show a difference of precisely 1 mile at all velocities below 9 miles per hour, indicated (10 miles per hour true). Above those limits the few available cases

show a steady decrease of the correction at the rate of about 10 percent for each mile above 9. These relations can be expressed in equations:

$$Y=X+1.0 \qquad (X\leqslant 9.0)$$
$$Y=0.9X+1.85 \qquad (X>9.0)$$

In the case of the four-cup anemometer the bend of the curve is so slight that a straight line can be fitted to give very satisfactory conversion of indicated to true velocities in the averages by months. To show how closely the monthly averages fall on the curve, and how nearly straight the curve really is, straight lines have been fitted by the method of least squares to the averages for the 20 years, 1905–24 for each of the 12 months, and for all together, as well as for seasons of more and less wind. The results of these calculations are gathered in table 1.

TABLE 1

Month	Average velocity			Regression coefficient			
	4-cup	True	Difference	b	Angle	a	$\bar{r}$
	1	2	3	4	5	6	7
					° ′		
January	10.57	10.43	−0.14	0.7802	37 58	2.18	0.9954
February	10.84	10.65	−.19	.7729	37 42	2.27	.9977
March	11.40	11.06	−.34	.7677	37 31	2.31	.9979
April	11.24	10.96	−.28	.7693	37 34	2.42	.9974
May	9.70	9.78	+.08	.7719	37 40	2.29	.9956
June	7.81	8.30	+.49	.8097	39 00	1.98	.9960
July	7.22	7.80	+.58	.8042	38 48	2.00	.9935
August	7.28	7.85	+.57	.8526	40 27	1.64	.9898
September	8.16	8.57	+.41	.7784	37 54	2.22	.9952
October	9.43	9.55	+.12	.7982	38 36	2.02	.9958
November	10.58	10.63	−.15	.7664	37 28	2.37	.9989
December	10.30	10.24	−.06	.7911	38 21	2.09	.9952
Year	9.57	9.64	+.07				
All months	9.56	9.65	+.09	.7826	38 03	2.17	.9994
September–May	10.27	10.21	−.06	.7754	37 47	2.25	.9984
June–August	7.44	7.98	+.54	.8205	39 22	1.88	.9921

The constants of the straight lines of best fit (Galton's lines of regression) are in columns 4 and 6 of table 1. From the last three lines of the table the following equations are derived:

$$Y=0.7826X+2.17 \qquad \text{(All months)}$$
$$Y=0.7754X+2.25 \qquad \text{(September–May)}$$
$$Y=0.8205X+1.88 \qquad \text{(June–August)}$$

Application of the first of these equations to the recorded means, for 26 years, gave "predicted" true velocities agreeing with the calculated values precisely in 70 percent of the cases, and differing no more than one-tenth of a mile in the remainder. Use of the second and third equations increased the number of coincidences to 75 percent while all the other differences remained exactly 0.1 mile. Other combinations were tried, without improving the result.

To show the closeness of the data to the same curve, the correlation coefficient, corrected for number of items, has been calculated, and is given in column 7. The values are phenomenally high, 0.99 to 1.00.

To show how slight is the turning of the curve in the part covered by the data, the angle of slope of each line of best fit is given in column 5. Another measure of the same thing is afforded by the values of a, the intercept on the Y axis, in column 6.

In the case of the four-cup anemometer, there is zero correction at 10.0 miles per hour, lower velocities are increased, and higher diminished. The effect on averages is indicated in column 3. At the level of wind velocity prevailing at Madison, Wis., the annual average velocity is little changed by conversion from indicated to true.

The values of Y from the equation for all months, are tabulated in table 2, for the benefit of anyone who wishes to test the results of this paper on data obtained elsewhere. Inasmuch as the comparison is independent of everything except the frequency distribution of wind velocities, comparable results should be obtained anywhere in the Central and Northern States.

TABLE 2.—*Conversion of monthly mean indicated (4-cup anemometer) wind velocities to true velocities*

	Indicated velocity (m. p. h.)										
	5	6	7	8	9	10	11	12	13	14	15
	True velocity										
0.0	6.1	6.9	7.6	8.4	9.2	10.0	10.8	11.6	12.3	13.1	13.9
0.1	6.2	6.9	7.7	8.5	9.3	10.1	10.9	11.6	12.4	13.2	------
0.2	6.2	7.0	7.8	8.6	9.4	10.2	10.9	11.7	12.5	13.3	------
0.3	6.3	7.1	7.9	8.7	9.4	10.2	11.0	11.8	12.6	13.4	------
0.4	6.4	7.2	8.0	8.7	9.5	10.3	11.1	11.9	12.7	13.4	------
0.5	6.5	7.3	8.0	8.8	9.6	10.4	11.2	12.0	12.7	13.5	------
0.6	6.6	7.3	8.1	8.9	9.7	10.5	11.2	12.0	12.8	13.6	------
0.7	6.6	7.4	8.2	9.0	9.8	10.5	11.3	12.1	12.9	13.7	------
0.8	6.7	7.5	8.3	9.1	9.8	10.6	11.4	12.2	13.0	13.8	------
0.9	6.8	7.6	8.4	9.1	9.9	10.7	11.5	12.3	13.0	13.8	------

2. *Influence of forest growth on wind velocity.*—The exposure of the anemometer at Madison, Wis. on the campus of the University of Wisconsin has been free from the changes ordinarily experienced at city Weather Bureau offices. The anemometer has been exposed on the same pole, and the only important changes in buildings were the erection of the Biology Building 500 feet away in 1910, and the burning of the dome on Bascom Hall in 1916.

In spite of the uniformity of the exposure, the records show a steady decrease of average wind velocity, and of the frequency of strong winds. The annual wind movement has decreased 510 miles per annum, and the annual total is now more than 15,000 miles less than it was in 1904 when the anemometer was set up. The number of days with maximum velocities has fallen off at the rate of 1.14 days per annum.

The only reason that I can think of for this change is the growth of the trees that form a thick forest on the slope down to Lake Mendota north of the station. The tops of the highest trees are now as high as the anemometer, and the general level of the top of the forest is only about 10 feet below the anemometer. This general level of the top of the forest has risen, I estimate, some 10 or 12 feet since I first saw it in 1908.

TABLE 3.—*Secular trend of wind velocity at Madison, Wis.*

Month	Average velocity, (4-cup)	Trend (miles per hour)	Percent	Standard deviation
January	10.4	−0.081	−0.78	0.83
February	10.7	−.115	−1.07	.84
March	11.3	−.024	−.21	1.14
April	11.2	−.073	−.65	.93
May	9.7	−.093	−.96	.71
June	7.9	−.033	−.42	.88
July	7.2	−.038	−.53	.55
August	7.2	−.050	−.69	.48
September	8.1	−.036	−.44	.50
October	9.3	−.098	−1.05	.78
November	10.7	−.045	−.42	1.11
December	10.3	−.019	−.18	.72
Year	9.5	−.057	−.60	.26

If the decrease of wind velocity is due to forest growth it is natural to expect the rate of decrease to be greater in summer, when the trees are in leaf, than in winter, when they are bare. In order to test this, secular trend lines were obtained by fitting a straight line to the data for each month and for the year by least square methods. The results are given in table 3.

The average trend in percentage is 0.68 for the 6-months May–October, when the trees are in leaf, 0.55 for November–April when bare. The coefficient of correlation of the annual wind velocity with the years is −0.84. The monthly data are much more variable and give smaller coefficients of correlation.

RECORD NOVEMBER FOG PRECEDING PHENOMENAL WINTER OF 1933–34 IN THE PACIFIC NORTHWEST

By ARCHER B. CARPENTER

[Weather Bureau, Portland, Oregon, June 1934]

The outstanding winter of 1933–34 was preceded, in November, by the greatest amount of dense fog ever recorded in the Pacific Northwest. Dense fog occurred at every airway and first-order station in the states of Oregon and Washington. The number of days with dense fog ranged from 3 at La Grande, Oreg., to 25 at Wolf Creek, Oreg.; the number of hours with dense fog during the month ranged from 5 at La Grande, to 217 at Eugene, Oreg. (See table 1.)

In a search for the cause of this unusual amount of fog, many interesting facts were discovered. The first is the relation between pressure distribution and the formation of fog. Using the Portland 4-hourly airway maps as a basis, all reports of dense fog in Oregon, Washington, southwestern Idaho, and northern California were tabulated according to the barometric pressure at the time when fog occurred. (See table 2.) This analysis was carried further by tabulating all hourly pressure reports, with or without dense fog, at the 27 airway and first-order stations. The percentage of possible hours with dense fog was then determined; the results are shown on graph A, figure 1.

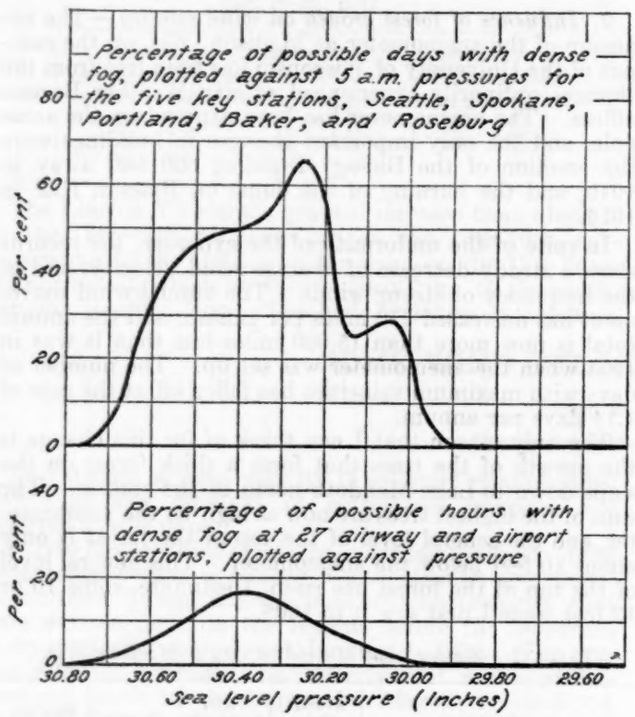

FIGURE 1.—Fog and pressure graphs for Pacific-Northwest, November 1933.

The relation between pressure and days with dense fog was developed for the five key stations, Seattle, Spokane, Portland, Baker, and Roseburg. The 5 a. m. pressure reports were arbitrarily chosen because they were closely associated with fog conditions. The pressures were tabulated according to station and day of month; then those for days on which dense fog occurred were segregated, and the percent of possible days with fog was determined for each pressure. The results are shown on graph B, figure 1.

It will be noted that 88.2 percent of the dense fog occurred at pressures of 30.2 inches or above. This leads directly to a major contributing cause—the pressure over the Northwest was 0.15 to 0.27 inch above normal for the month of November, and thus was well within the limits favorable to formation of fog.

A review of storm tracks during the month will, in part, explain the unusually high pressure. On the 2nd of November a storm moved west to east through central Washington. From that time until November 27, no storms moved in through the Pacific Northwest. However, 9 storms did move in just north of Prince George, through a belt some 600 to 900 miles north-northeast of Portland, Oreg.; this distance seems to be ideal for fog formation in Washington and Oregon.

November 1933 eclipsed all previous years of record with a collective total of 58 days with dense fog at the stations of Seattle, Spokane, Portland, Baker, and Roseburg. These stations were selected because their length of record facilitates comparison with other years having excessive fog. Second in rank is November 1905, with a collective total of 43 days with dense fog; storm tracks were all north of Prince George, British Columbia, except one on the last day of the month. Then follows the year 1917, with a November collective total of 41 days with dense fog; all storms moved in north of Prince George. Next in rank are the years of 1923, 1922, and 1907; for these years similar conditions prevailed, except that a storm track through the Northwest in the opening days of November becomes more prevalent. In a study of other years with large collective totals, it becomes evident that the collective total of days with dense fog for the Northwest *decreases* in proportion to the number of storms moving inland *south* of Prince George.

A storm moving in through the Northwest very early in November, or late in October, is favorable to production of fog. The immediate reason is evident, as radiation fog is common in a stagnant, saturated air-mass from the Pacific Ocean. When such an air-mass is allowed to stagnate, fog sets in quickly and soon becomes widespread. Stagnation, however, depends on a new series (1) of LOWS starting immediately through the channel mentioned, just north of Prince George. This new series effectively shuts off the usual outburst of dry continental air following the eastward movement of a storm. Such an outburst of dry, cold air through the Northwest would quickly wash the stagnant, saturated

air-mass out to sea. Insolation following such an outburst of continental air is usually sufficient to eliminate any possibility of widespread fog. However, with the new series of storms following one after another, through the channel north of Prince George, no continental air is allowed to reach the Pacific Northwest. The latter condition was fulfilled almost perfectly during November 1933.

Nearly all intermissions between days with dense fog came when storms passing inland reached unusually large size, thus bringing the Pacific Northwest under the influence of the storm, and causing an overcast condition instead of fog, with a small amount of accompanying precipitation.

The interplay of November rain and fog at Portland is interesting, and can briefly be stated as follows: Light to moderate rain on 1st to 3d, inclusive (total 1.83); dense fog reported on 6th to 11th, inclusive; light rain on 11th and 12th (trace); light rain on 15th and 16th (total 0.03); dense fog reported on 16th to 20th, inclusive; light rain on 19th (total 0.31); light rain on 21st (total 0.01); dense fog reported on 22d and 23d; light rain on 23d and 24th (total 0.05); dense fog reported on 25th and 26th; light rain on 26th and 27th (total 0.31); dense fog reported on 29th. This was definitely the end of the foggy weather, which was followed by a period of rain during December, with an excess of 10.73 inches at Portland over a normal of 6.72 inches. The deficiency in November precipitation for Portland was 3.56 inches below a normal of 6.10 inches.

The above November deficiency for Portland is strongly in contrast with an excess of 4 inches at Juneau, 8 inches at Ketchikan, 13 inches at Prince Rupert, 26 inches at Swanson Bay, and 22 inches at Ocean Falls. Precipitation at each of the last three stations along the Canadian west coast was more than double the normal November rainfall. The precipitation at Estevan, British Columbia, was nearly normal; and southward along the Washington and Oregon coast it was increasingly below normal. The above data are introduced to show the effect of a continuous series of storms moving consecutively over one track.

A closer study of the relation between fog in the Pacific Northwest and heavy rainfall along the coast of Canada and southern Alaska reveals facts of considerable interest. The first long period with dense fog followed a storm moving in through the Northwest on November 2. Fog conditions thus produced were maintained by another storm in the Gulf of Alaska which gave Ketchikan 1.98 inches precipitation on the 5th, 6th, and 7th. Following a 1-day lull, another storm gave Ketchikan a 3-day total of 4.60 inches. Then followed another 1-day lull, in the wake of a large storm which later produced the duststorm of November 12 and 13, 1933. This storm covered a wide strip from South Dakota eastward to the St. Lawrence Valley. Portland, Oreg., had a full day of sunshine on November 13 and almost a full day on the 14th. On the above 2 days Ketchikan received 4.8 inches precipitation. It was the southeast return of air from this storm that again produced ideal fog conditions in the Northwest by November 16. Five days with dense fog at Portland followed. This fog condition was maintained similarly to the first one, that is, by another storm immediately following, which gave Ketchikan 6.52 inches of rain on November 17 and 18. Rainfall at Ketchikan also reached a maximum during each of the remaining shorter fog periods. A short review of previous years likewise reveals a close association between heavy rainfall at Ketchikan and prolonged fog in the Pacific Northwest (fig. 2).

This series of storms, passing inland just to the north of Prince George, British Columbia, produced interesting effects in the air masses over the Northwest. The air-mass designations are those used by Willett (2), and a careful attempt has been made to classify the air masses according to his specifications. Use was made of forenoon temperatures aloft, as reported by commercial aircraft every few minutes while in flight; upper-air wind directions and velocities from pilot-balloon ascensions; air-mass trajectory from Map A Pacific; and surface temperatures, dew points, and wind records from 4-hourly airways maps prepared at Portland, Oreg. Upper-air humidity records for November were not available, thus injecting considerable uncertainty into classification.

The air mass on November 6 was classed as Neutralized Polar Pacific (Npp) air in the low levels, and Neutralized Tropical Pacific (Ntp) air aloft. The Npp air was a stagnation of the fresh Polar Pacific (Pp) air that remained in the Pacific Northwest after the storm of November 2 had passed inland. The Ntp air aloft had

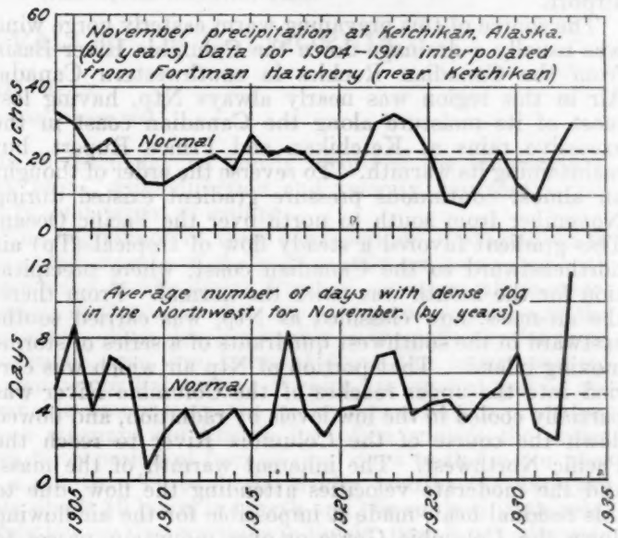

FIGURE 2.

its source in a large portion of the Pacific HIGH, which had been pushed into southwestern Canada by a storm developing in the usual location of the Pacific HIGH. Portland winds aloft on November 6 were northerly up to 10,000 feet, with a tendency to north-northwest in the higher levels. The entire mass up to 7,000 feet was almost isothermal, except for a low inversion layer. Actual temperatures ranged from 48° F. to 52° F. at altitudes between 2,000 and 7,000 feet. No reports were available above 7,000 feet. The low inversion extended to approximately 2,000 feet at 10 a. m. with surface temperature 41° and dew point 40°. By afternoon, when the fog and low stratus clouds cleared away, nine-tenths of the sky was covered with alto-cumulus clouds moving from the northwest.

In the days following November 6, the top of the inversion increased steadily in height and temperature, reaching a maximum height of 6,000 feet November 12 with a temperature of 70°. The surface dew point at Portland increased slowly from 40° to 44° on the above

6 days. Available upper-air wind reports indicated a predominance of southwesterly winds of moderate velocity above 4,000 feet and southeasterly winds of moderate velocity below that altitude. These southeasterly winds were mostly of Columbia Gorge origin. The temperatures at Crown Point, elevation 743 feet, at the western end of the Columbia Gorge, averaged 1° lower than Portland airport temperatures during foggy weather. Adiabatic heating of this air as it reached lower elevations in the Portland area was sufficient to maintain the flow at an elevation above the surface fog stratum. The following relation holds true in nearly all cases. With easterly velocities under 25 miles per hour at Crown Point, and temperatures not more than one degree colder than at the Portland Airport, no turbulence whatever was noted in the fog stratum at the airport. With greater velocities and similar temperatures, the turbulence was felt in proportion to the increased velocity, with resultant slow dissipation of fog. With temperatures at Crown Point equal or slightly higher than at the Portland airport, easterly velocities in excess of 40 miles per hour at Crown Point were needed to produce turbulence in the surface fog stratum at the airport.

The source of this prevailing warm easterly gorge wind was usually a drainage down the Columbia River Basin from the Canadian Rockies in southwestern Canada. Air in this region was nearly always Ntp, having lost most of its moisture along the Canadian coast in the excessive rains at Ketchikan and Prince Rupert, but maintaining its warmth. To reverse the order of thought an almost continuous pressure gradient existed during November from south to north over the Pacific Ocean. This gradient favored a steady flow of tropical (Tp) air northeastward to the Canadian coast, where precipitation for the month was twice the normal. From there, the air-mass, now classified as Ntp, was carried southeastward in the southwest quadrants of a series of storms moving inland. That portion of Ntp air which was carried into the upper reaches of the Columbia River was partially cooled in the low levels by radiation, and flowed down the course of the Columbia River to reach the Pacific Northwest. The inherent warmth of the mass, and the moderate velocities attending the flow, due to this residual heat, made it impossible for the air flowing down the Columbia Gorge or over mountain passes to affect the fog strata in the coastal valley from Seattle to Roseburg. The heating produced by the warm air passing over these fog strata was balanced by radiational cooling during the lengthening November nights. This radiational cooling also had to overcome the afternoon insolation when fog and low clouds cleared away.

The only days during this November with 100 percent sunshine at Portland, came on November 5 and 13. The 5th was previous to the beginning of fog at Portland, and the 13th followed a temporary lapse in the storm series north of Prince George, allowing additional cooling in the air flow down the Columbia River drainage. On November 12, at 10 a. m. the air at Crown Point was 6° colder than at Portland, quite in contrast to the 6 days just preceding, when 10 a. m. temperatures at Crown Point were very nearly equal to those at Portland. The temperature of the air for these 6 days, reduced to Portland elevation, would have been higher, but the Crown Point temperature on November 12, even when reduced to Portland elevation would still be lower. The result was a washing out of the foggy stratum in the Portland area. However, the flow was not strong enough to materially affect the foggy strata in the Willamette Valley and Roseburg areas.

Air-mass conditions for the second long period of fog from November 16 to 20, were very similar to those for the first period. The original cold surface fog stratum was formed in Npp air; upper air temperatures and winds were almost identical, and a similar relation prevailed between temperatures at Crown Point and Portland. While the Portland area has been used as an example, the relations apply to the whole coastal valley to a lesser extent, applying least in the Roseburg area.

A relation also exists between fog in the Northwest and a preceding cold winter in central Alaska. The record at Fairbanks began in 1904, and was chosen as being the best available; 73 percent of the years with November fog above normal in the Northwest were preceded by subnormal winter temperatures at Fairbanks. Most interesting are the 3 years, 1907, 1917, and 1933. The mean temperature for the 3 months of the winter of 1906–7 was −12° F. (The normal mean temperature for the 3 winter months at Fairbanks is −5.5°.) In November 1907 the Northwest had an average of 7 days with dense fog. This average is based on records for the stations at Seattle, Spokane, Portland, Baker, and Roseburg. (The normal average for these stations is 4½.) For the winter of 1916–17, the mean temperature was −8.3° at Fairbanks, and the following November produced an average of 8 days with dense fog in the Northwest.

The winter of 1932–33 at Fairbanks (3) was severe, with a mean temperature for the 3 winter months of −14.5°. November 1933 followed with an average of 12 days with dense fog at the above-mentioned stations in the Northwest. The average for November 1933 was taken from regular Weather Bureau office records, so that it would be comparable to other records before the advent of airport stations. Substituting airport records for city office records, where possible, the average is increased to 14.

It is interesting to note that floods occurred in the Willamette River in December 1907, 1917, and 1933, and that heavy floods occurred in western Washington (5) in the last 2 years mentioned above. The Novembers of 1917 and 1933 were both preceded, and followed, by record-cold temperatures in central Alaska. On January 27, 1933, the temperature dropped to 60° F. below zero, and this temperature was also reached in 1916, just previous to the November and December phenomena in 1917. The years 1917 and 1933 both ended in unusually mild winters in the Northwest, and severe winters throughout Alaska and the Northeastern States (4).

There is a strong possibility that records covering a longer period may show a correlation between severe winters in central Alaska, November fog and December floods in the Northwest, and severe cold in the Northeastern States.

TABLE 1.—*Days and hours with fog in Northwest for November 1933*

Station	Light fog		Moderate fog		Dense fog	
	Days	Hours	Days	Hours	Days	Hours
Portland-Medford Airway:						
Portland, Oreg.	23	106	18	103	16	88
Salem, Oreg.	25	104	22	76	19	133
Eugene, Oreg.	25	111	20	65	22	217
Roseburg, Oreg.	26	95	17	54	23	169
Wolf Creek, Oreg.	0	0	6	6	25	165
Sexton Summit, Oreg. (elevation 3,855 feet)	2	3	1	2	7	81
Medford, Oreg.	16	51	11	17	15	109
Portland-Seattle Airway:						
Castle Rock, Wash.	26	283	22	62	19	111
Chehalis, Wash.	28	178	21	83	15	88
Tacoma, Wash.	24	125	19	103	18	187
Seattle, Wash.	28	223	21	101	15	71
Portland-Pasco-Spokane Airway:						
Portland, Oreg.	23	106	18	103	16	88
Crown Point, Oreg. (elevation 743 feet)	14	36	6	8	13	82
Cascade Locks, Oreg.	14	40	3	6	7	29
Hood River, Oreg.	17	41	6	11	3	13
North Dalles, Wash.	12	57	3	5	5	16
Umatilla, Oreg.	8	39	7	16	5	22
Pasco, Wash.	8	38	3	8	3	15
Spokane, Wash.	16	74	10	22	9	61
Pasco-Boise Airway:						
Pasco, Wash.	8	38	3	8	3	15
La Grande, Oreg.[1]	5	9	2	6	3	5
Baker, Oreg.[1]	5	15	4	10	4	15
Weiser, Idaho.[1]	5	6	13	26	15	59
Boise, Idaho	9	23	0	0	0	0

[1] Data for intermediate stations on this airway interpolated from sequence reports.

TABLE 2.—*Reports of dense fog at 4-hourly periods with pressure at which fog occurred and percentage of cases*

Total cases reported November 1933	Sea-level pressure	Percentage of cases	Total cases reported November 1933	Sea-level pressure	Percentage of cases
	Inches			*Inches*	
6	30.00–30.09	1.2	104	30.40–30.49	20.8
53	30.10–30.19	10.6	19	30.50–30.59	3.8
125	30.20–30.29	25.1	2	30.60–30.69	0.4
189	30.30–30.39	37.9	1	30.70–30.79	.2

LITERATURE CITED

(1) Bowie, Edward H., The Remarkable Occurrence of Cyclones in Series; Monthly Weather Review, Washington, D. C., September 1933.
(2) Willett, H. C., American Air Mass Properties, Massachusetts Institute of Technology, Meteorological Papers, Vol. II, No. 2, Cambridge, Mass.
(3) Frost, R. L., The Winter of 1932–33 at Fairbanks, Alaska, Monthly Weather Review, November 1933.
(4) Pierce, Charles H., The Cold Winter of 1933–34, Bulletin Am. Met. Society, March 1934.
(5) Jermin, T. E., Floods and Slides in Washington, December 1933, Climatological Data, Washington Section, Seattle, Washington, December 1933.

WINTER FOGS IN THE GREAT VALLEY OF CALIFORNIA

By R. C. COUNTS, Jr.

[Weather Bureau, San Francisco, Calif., August 1934]

An effort is made in the following discussion to establish two facts concerning fogs in the Great Valley of California: First, that the more extensive fogs have their inception only after the first seasonal rains, and that their development at any time during the winter is dependent on a wet ground. Second, that in the initial stages of their development they appear as ground fogs, or as fogs with the lower surface resting on or within a few feet of the ground,[1] rather than in the form of stratus cloud.

This Great Valley, which comprises the Sacramento and San Joaquin valleys, is an elongated area covering 20,000 square miles, roughly, and is surrounded by mountains averaging approximately 3,000 feet in height on the westward side, and more than 5,000 at the northern and southern extremities and on the eastward side. By the configuration of the land, the valley is protected from any horizontal movement of the air, except through a few passes in the coastal range, a condition which permits atmospheric stagnation, and favors its prolongation. It is during these quiescent states that protracted spells of fog and stratus cloud occur in the winter months; fogs of such extent and persistence as to impede or prevent travel by auto, train, or airplane, and therefore of much concern to operators of public conveyances. Some concept of the extent of these fogs may be acquired from the fact that during January of 1934, there were 350 hours with fog or stratus cloud, at no time with a ceiling higher than 1,000 feet, at Fresno, and 335 hours at Sacramento, or very nearly one-half of the entire 744 hours of the month. Fogs with their inferior surface resting on the ground occurred in varying degrees of intensity on 28 days of this month at Fresno and on 23 days at Sacramento. In this connection it is well to state that the data in this paper were obtained from the charts at the San Francisco office of the Weather Bureau and from the forms of the various airport stations in the valley. These forms contain for each day an hourly record of the temperature, dew point, wind direction and velocity, horizontal visibility, and height of ceiling.

The beginnings of these long periods of stagnation in the cooler months of the year usually are associated with subsidence in the Polar Pacific[2] air-mass which overspreads the far west after the passage of a cyclone to the eastward. Fogs develop readily in the valley under these conditions, and are frequent from the latter part of November to February. If rains are general and of appreciable amounts in the valley immediately preceding these stagnant conditions, fog often engulfs the entire area for a period of from several days to the major part of a month. Through the winter months the days are only about 10 hours in length and the sun's altitude relatively low, so that warming in the daytime is not adequate to offset the loss of heat by radiation during the much longer nights from the ground and the moist stratum of air usually confined in the valley under stagnation. Fogs do not occur in this season alone; they also form in the early spring and late fall, but with considerably less frequency, and usually are of short duration. This, of course, would be expected since the nights are much shorter, and nocturnal cooling by radiation is too often insufficient to lower the temperature to the dew point through the required depth of moist air.

The first occurrence of fog in the season occasionally is in the fall months after there has been a definite trend to cooler weather and the nights have become materially longer. But, it is almost axiomatic with the district forecasters at the Weather Bureau office in San Francisco that fogs or stratus clouds of a general character do not develop until after the first seasonal rains; and that if their development does not follow within a few days of the first rainy spell it will be delayed until after a later rain. The close relation between rains and fogs in the

[1] Dense fogs of considerable thickness; the term "ground fog" applies to fog which obscures objects on the ground, but does not materially obscure the sky. Both types are to be distinguished from stratus cloud or "high fog".

[2] Referred to in this paper as such, although it usually is modified or transitional Polar Pacific air.

Great Valley is one of prime importance in understanding and forecasting the development of these fogs, and is the one of two precepts which necessarily must be established first.

For this purpose a study was made of the initial rains and fogs of each season during the 30-year period from 1904 to 1933, inclusive, at Red Bluff and Fresno, representing, respectively, the northern and southern portions of the valley; and during a 29-year interval, beginning 1 year later, at Sacramento, which is situated in the central and lower part of the valley near the confluence of the Sacramento and San Joaquin Rivers. Through all of these years there were only two cases of any fog at Fresno prior to the first rain of the season, only one case at Sacramento, and none at Red Bluff. In just 3 years out of 30, and at only 2 of the 3 stations, did fog develop before the first rain—a significant fact overlooked in the many discourses published on the causes of fog formation, and even more significant when on examination of these three instances it is found that the fogs were merely local in character and occurred for a short time only near sunrise on not more than 3 days. Unquestionably these fogs were quite shallow, and a result of cooling by radiation of a thin stratum of relatively moist air in the low lands.

It does not necessarily follow that the formation of fog begins after the first rain and before the second rainy period; in fact, the more general fogs would not develop if the stagnated air-mass were of Polar Continental origin and hence had very low specific humidity; nor would they develop if there were an early displacement of the Polar Pacific air over the valley by an air-mass of different characteristics, or if turbulence were too great, or if the temperature element were not suitable, or if the rain were too light to thoroughly wet the soil which has become parched and dry at the end of the long desiccating summer. Too, there is a certain band of temperatures above and below which the more extensive and tenacious fogs do not develop. Observers suggest that this band extends from near the freezing point to approximately 50° F., and a cursory examination of a few instances substantiates this suggestion.

In the 28 years in which no fog was observed before the first rain, there were 4 years at Fresno and 5 at Sacramento in which fog formed after the first rains, but their formation was delayed more than a week after any rain, whether it was the first seasonal rain or not. Red Bluff was not considered in this phase of the study, as it was frequently impossible to distinguish stratus cloud from cloud arising from other causes. Again, in these instances the fog was rather local, and not the more general type with which this paper is concerned. Furthermore, in all years of the record investigated the intense fog situations developed within the limited time of 7 days after the first or a subsequent rain.

We cannot escape the fact, then, that the more widespread and prolonged fogs have their inception not only after the seasonal rains have begun but within a period of a few days or a week of these rains. Of course, the foregoing discussion applies primarily to the initial fogs of the season, but innumerable cases of fogs on later dates have been examined and they were invariably preceded by rain by not more than about a week. There are no apparent physical reasons by which to refute a deduction that rain is a prerequisite of fogs in the valley at any time during the season, as well as of the initial fogs. Conditions are similar, and the factors involved are in the same relation to each other, whether it be in connection with the first fogs or those of a later date.

Without a wet valley floor, regardless of the water vapor content of the Polar Pacific air that overspreads the valley at the outset of a period of atmospheric quietude, fogs will not materialize, except possibly those of a local character. A careful study of some typical cases shows that evaporation of moisture from the wet ground into the lowest stratum of air is the final link between those instances productive of fogs and those nonproductive of fogs, all other factors being similar in each one. The amount of moisture accumulated in the lower layers of the air from the wet ground varies considerably between individual instances. Influenced by several factors, the amount existing at different points in the valley also shows a rather wide variation. Those instances examined showed an increase of from one to five grams per kilogram in the moisture content of the lower air stratum as a result of evaporation. Frequently the water vapor content of the air was increased more than twofold.

When the Polar Pacific air encroaches on the Pacific Slope, its specific humidity is rather uniformly distributed up to a height of several thousand feet. Usually the occupancy of the valley by this newer air-mass is immediately preceded by rain in the valley, in which case evaporation from the wet ground increases the water vapor content of the lowest layers of this air. Simultaneously with, and as a result of, this evaporation the heat of vaporization decreases the temperature or impedes any rise in temperature of the ground. Often a part of the mass of air associated with the cyclone is entrapped in the valley by the cooler and somewhat drier air; especially is this true of the San Joaquin Valley. This in no way alters the fog conditions; in fact, it is favorable to fog formation by increasing the water vapor content of the newer air-mass. In other instances, where the anticyclone spreads over the valley about a week or more after rain has fallen, there is no general fog development; or if the development does not begin within about a week after the rain, it is delayed until the cycle of events is repeated on a later date. The explanation is offered that during a period of approximately a week after rain, the ground has become quite dry due to evaporation—usually an almost cloudless sky follows periods of unsettled, rainy weather, unless fog develops. This evaporated moisture is diffused to considerable heights, and much of it carried away by the end of a week or more. Therefore, there can be no appreciable addition of water vapor to the low levels of an air-mass that overspreads the valley later than a week after rain. Neither can there be any concentration of water vapor in the low levels later than a week after the rain, since then the ground will have become too dry again to yield any material amount of moisture.

In those cases which lead to the development of the more general and tenacious fogs, evaporation from the wet soil results in the addition of moisture to the atmosphere, and a decrease in temperature of the ground. This process, however, is not completed in 1 day; sometimes it may extend over the greater part or all of a week, during which time the specific humidity is progressively increased and the surface temperature decreased or its rise retarded. Unmistakably the inference is that ground fogs or fogs with their surface on or near the ground make their appearance first, followed later by deeper and more persistent fogs as evaporation and cooling continues. Subsequently, as the subsidence inversion developes, stratus cloud makes its appearance.

This inference brings us to the second precept set forth above, which is justified in view of the many cases of fogs

examined, all of which revealed the presence of ground fogs or fogs with their inferior surface resting on or near the ground before the appearance of stratus cloud. During the winter of 1933–34, there were three prolonged foggy periods, December 20 to 28, January 3 to 21, and January 28 to February 4 (all dates inclusive), and in each case low fogs were general throughout the valley for several days prior to the observance of stratus cloud. When an anticyclone overspreads the valley, evaporation from the wet soil begins, and the water vapor content of the lowest layers of this air is increased while the heat of vaporization lowers, or impedes any rise in, the temperature of the ground. Radiation from the ground and from this stratum of air, in which there has been a concentration of water vapor, results in fogs during the night and early morning, which in their early stages are shallow and of short duration. On succeeding days evaporation continues, but convection, even though feeble on these short winter days, and turbulence carry some of the added water vapor to increasing heights, with the result that recurrent fogs become deeper, more general, and of longer duration. Too, after the fog has developed, it and any uncondensed water vapor in or above it, continue to radiate heat, at a considerable rate, while the return radiation from the much drier air above is negligible, so that there is a marked net loss of heat by the fog. There is a net loss by it in the daytime also, though not quite so large, because nearly 80 percent of the incident solar radiation at the top of the fog is reflected while the emission from the fog is unchanged. Therefore, just as radiation of heat from the ground and moist air stratum is the cause of the formation of fogs, so is it the means by which they are maintained as well as increased in thickness. Ultimately the fogs become increasingly difficult to disperse, and when the subsidence inversion is established they continue throughout the day.

The inferior surface of the fog becomes quite variable now, and may rest several hundred feet above the ground as often as on the ground. During the daytime a portion of the remaining 20 percent of the solar radiation not reflected by the fog penetrates to the ground, and the warming that ensues, though slight indeed, is ample to dissipate the lower stratum of the fog. This thinning occurs in the nighttime as well, due to the fact that long wave radiation from the ground is absorbed readily by the fog particles which absorption tends to warm this layer, and gradually dissipate the fog near the ground; but all the while, loss of heat by radiation from the fog is proceeding rather rapidly with the result that its upper layers become denser. The fog is not necessarily dissipated altogether near the ground, but may continue in varying degrees, either day or night, with a horizontal visibility ranging from one-fifth mile to several miles. However, the air temperature and dew point rarely become separated by more than one or two degrees under this stratus cloud; therefore it follows that a slight change in temperature, or possibly in some other factor, would result in the redevelopment of dense fog. Hence, while stratus cloud, or "high fog", continues unbroken it frequently extends to the ground in varying degrees of density, and this condition persists until the air-mass involved is displaced by one of different characteristics. Some years ago E. H. Bowie, in connection with his long study of summer fogs in the California coastal region, also observed a relation between winter rains and fogs in the interior valleys. W. E. Bonnett, in charge of the Fresno office of the Weather Bureau for many years, included the following statement in an official letter some time past: "Briefly, observation and the records show that the high fogs, so-called, in the San Joaquin Valley, have their beginnings in ground fog."

The accompanying graphs and chart illustrate to some extent the conditions favorable to, and the physical activity in process during, the development of a protracted spell of fog. This period, January 24 to February 4, 1934, covers the last of these anticyclonic periods of "gloom" of the past winter 1933–34, and would be a typical instance but for the belated development of fog. On January 23 light to moderate rains fell throughout northern California, and by the afternoon of this date the

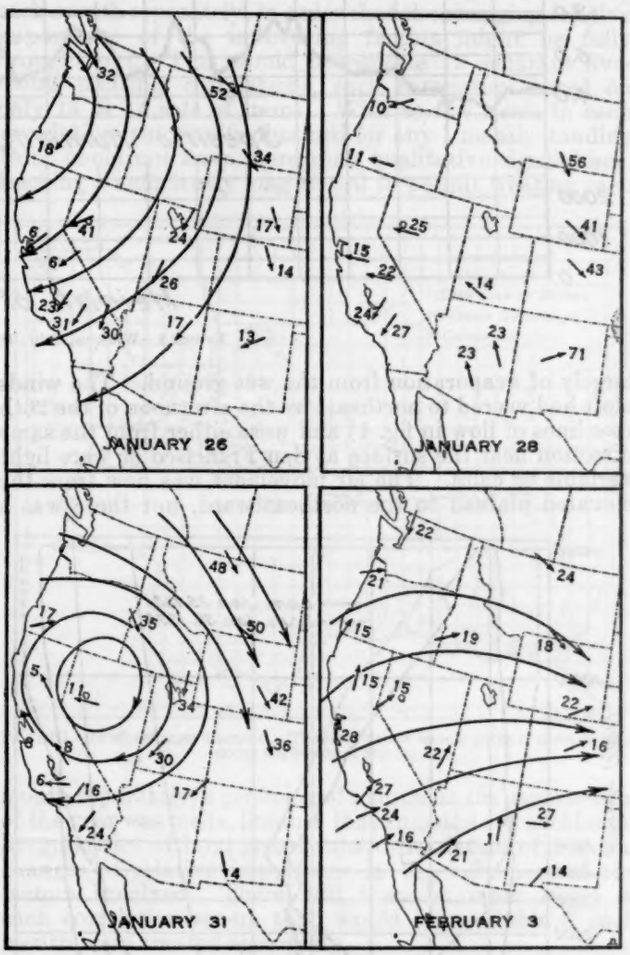

FIGURE 1.—Wind at 12,000 feet (3 p. m.).

Polar Pacific air made its appearance along the Pacific slope. Clearing skies and decreasing specific humidity began on the same afternoon, and by noon of the 24th the specific humidity at San Francisco and Williams (located in Sacramento Valley) had decreased to approximately 3 parts per 1,000, or about one-half the value on the preceding day. The average on the 24th was 3.3 g/kg at San Francisco and 3.8 g/kg at Williams.

Northerly gales prevailed aloft on the 24th and 25th, but near the surface at San Francisco the wind was light to moderate north or easterly or calm, and the center of this new air-mass was over Oregon. Under such wind conditions there could be little additional air transported directly from off the ocean; even so on the first day this

is shown to possess a water vapor content of not more than 4 g/kg. However, there was a sharp increase in the water vapor content of the air in the valley from the afternoon of the 24th to the 25th (fig. 2), unquestionably the result

The center of the anticyclone had advanced to the central Great Basin by the morning of the 30th, but after the 28th there had been a steady decrease in intensity. This would indicate subsidence was in effect over the far west.

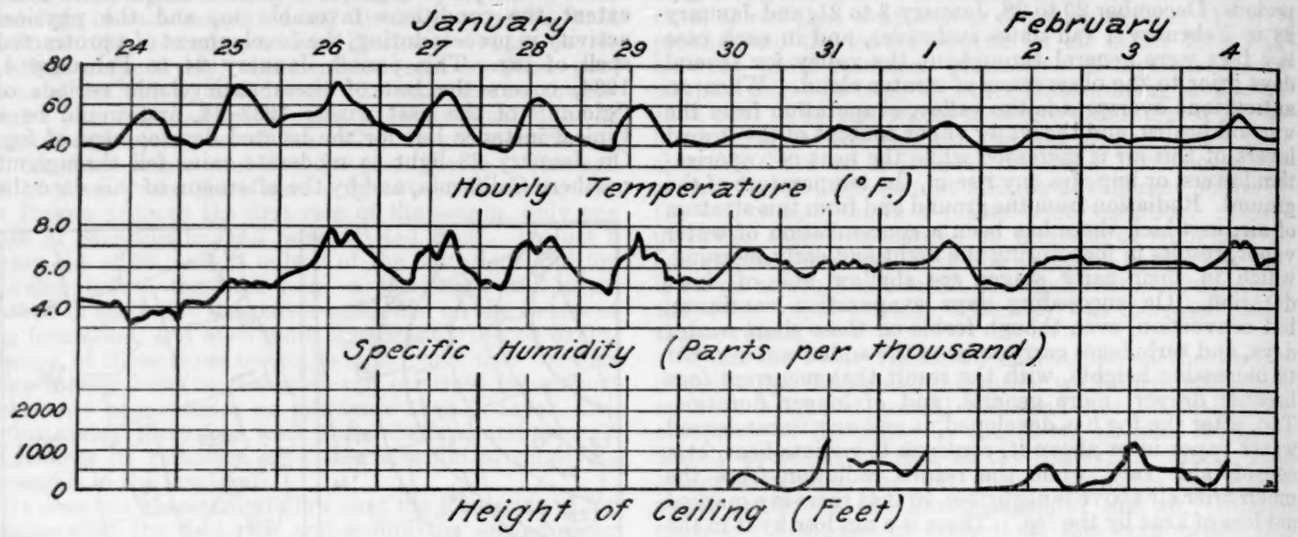

FIGURE 2.—Williams, Calif., January 24–February 4, 1934, inclusive.

largely of evaporation from the wet ground. The winds aloft had veered to northeast by the afternoon of the 26th (see lines of flow in fig. 1) and were either from the same direction near the surface at San Francisco or were light variable or calm. The air movement was now from the elevated plateau to the northeastward, but there was a

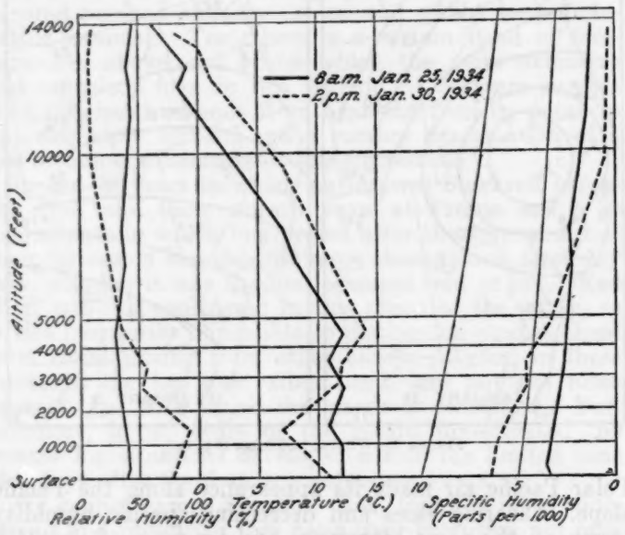

FIGURE 3.—Sunnyvale, Calif.

further sharp increase in the absolute humidity in the Great Valley. The average specific humidity at Williams on the 26th was 7 g/kg, an increase of 3.2 g/kg or 46 percent over the average on the 24th. This can be accounted for in large measure only by means of the addition of moisture from the ground.

An anticyclonic circulation also appeared in the upper air over the region west of the Rocky Mountains, with the center over Nevada, and light southeasterly winds prevailed over California (fig. 1). This also indicated subsidence over the Great Valley. Note the higher temperatures above 3,000 feet at Sunnyvale on January 30 (fig. 3) and the appearance of an inversion of temperature below this level. There had also been an increase in both the relative and absolute humidities below 5,000 feet, and a corresponding decrease above this level. Fog had developed during the night of the 29th–30th over much of the Great Valley; the first at Williams was just past midnight. It was a dense fog with a ceiling of zero, indicating conclusively that it was resting on the ground rather than in the form of stratus cloud. This dense fog continued until noon of the 30th, but had again extended to the ground by 10 p. m. Beginning with February 2 and continuing until the afternoon of the 4th, the sky was overcast, with the ceiling varying between zero and 1,200 feet. On the morning of the 2d the winds aloft over California had definitely shifted to the southwest with increased velocities, and it was obvious that the foggy regime would not be long-lived. During the latter part of the 4th and the morning of the 5th this new air-mass penetrated into the valley, and the last fog of the season was definitely ended.

The effects of afternoon convection are clearly depicted on the specific humidity chart (fig. 2), and it is interesting to observe the immaterial diurnal range in temperature and specific humidity during the days when fog prevailed. It is also interesting to note the well defined anticyclonic circulation in the upper air during the period just prior to and during the fog, as indicated by the lines of flow drawn on the charts in figure 1.

REGRESSION EQUATIONS ANALYZING THE IMMEDIATE ANTECEDENTS OF TEMPERATURE ANOMALIES IN STRAITS OF FLORIDA SURFACE WATER

By GILES SLOCUM
[Weather Bureau, Washington, December 1934]

The causes of variations in the Straits of Florida water-surface temperatures are many and complex. To analyze these causes into their ultimate constituent components would be a difficult and delicate task, perhaps leading to precariously tenable conclusions. In the present paper, no such minute unraveling is attempted. Instead, what are admittedly complexes of several basic elements are treated, partly for simplicity and convenience, as single "causes."

Subject to this grouping, practically all of the variations in straits surface temperatures may be expressed in terms of simple, linear, algebraic functions of the combined influences of three numerical factors. In other words, the fluctuations in these three modifying factors can be made to account for practically all of the fluctuations in the Straits of Florida water-surface temperature anomalies. These factors are, in approximate order of decreasing importance:

1. The contemporary local air temperature (that of Key West was used).
2. The water temperature in the eastern Gulf of Mexico.
3. The contemporary percentage of possible sunshine at Key West.

The temperatures in the eastern Gulf are significantly correlated with both the straits temperatures of the same month and those of the following month. Therefore, the closest fit of computed values to actual temperatures is obtained by a twofold use of the numerical quantities representing the eastern Gulf of Mexico surface-water temperature anomaly influence. Counting the dual influence of the eastern Gulf as two variables, and including the dependent variable, straits temperature anomalies, this makes the total number of variables equal to five.

There are, of course, other factors and influences which have been considered at one time or another to be highly significant in their effects upon variations in straits surface temperatures, and many of these have received considerable study. Some of these factors and influences probably modify the straits water-surface temperature fluctuations about their seasonal normal by amounts which are large in an absolute sense—in the number, let us say, of ton-calories of heat per second passing a given cross section of the straits—but yet in relative importance are comparatively minor. Examples of such factors would include:

1. The surface temperature variations in the Caribbean Sea.
2. The amount of local rainfall, or that for some distant point.
3. The movements of wind insofar as these movements produce effects independent of the complex of effects here grouped under "air temperature."

The locations and boundaries of the areas considered are shown on the map (fig. 1). It will be noted that the area defined as the "eastern Gulf" overlaps slightly that designated as the "Caribbean Sea."

The period available for study was July 1920, to November 1933, inclusive, or 13 years and 5 months. The items correlated, in the case of the temperature data, were the departures of the monthly averages from their own 13-year or 14-year means or "normals." In the case of the Key West sunshine, the full positive decimal fractional values of sunshine for the month were used, in the computations, with unity coded to mean 100 percent.

The amount of correlation between the influencing factors selected as significant and the straits water temperature varies from one part of the year to another. For this reason, there would be advantages in treating each month separately, in order that the changing relative importance of the influencing factors might be fully brought out. This would necessitate 12 separate five-factor multiple correlations, each correlation based on only 13 or 14 sets of items. With so few items in each correlation, the results obtained for any 1 month standing alone could not have more than qualitative significance. Lacking a sufficiently long record to permit treating each

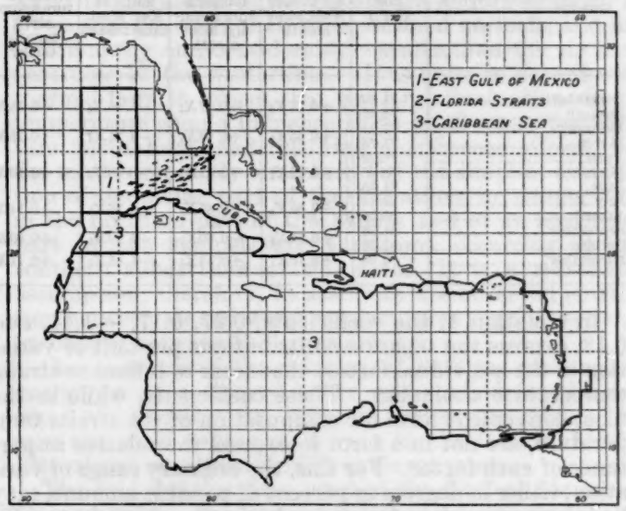

FIGURE 1.—Limits of areas discussed. The arrows show annual paths of currents traversing the Straits of Florida.

month separately, a grouping of months in the same season of the year was made, because that smooths out accidental irregularities without greatly obscuring details of seasonal changes of relative importance in the influences of the factors involved. There will then be more items in each correlation set-up than would be available if each month were treated separately.

Table 1 shows the regression equations computed, by this plan, from the available data. As an example of the meaning of the table, consider a sample month, December.

During this month, the basic theoretical temperature of the straits water, assuming all the influencing temperatures to be exactly normal and no sunshine to have occurred at Key West, is 77.62° F. The temperature for any particular December is then given by the equation:

$$X_1=77.62°+0.27X_2+0.17X_3-1.44X_4+0.18X_5 \quad (1)$$

For instance, in December 1929, X_2, the air temperature of Key West, was 2.02° below normal; X_3, the eastern Gulf of Mexico water temperature, was 0.10° below normal; and X_4, the proportion of possible sunshine during

the month at Key West, was 56 percent. In November, the preceding month, X_5, the water temperature in the eastern Gulf of Mexico, was 0.25° above normal. Therefore, the computed straits surface temperature for December 1929 was:

$$77.62°+(0.27\times-2.02°)+(0.17\times-0.10°)-(1.44\times0.56°)+(0.18\times0.25°)=77.62°-0.02°-0.55°-0.81°+0.04°=76.28°$$

The discrepancy between computed and actual straits sea-surface temperatures was the actual temperature, 76.45°, minus the computed temperature, 76.28°, or 0.17° in this instance.

TABLE 1.—*Regression equations, straits of Florida mean surface temperatures; computed by least squares in terms of 4 influencing factors*

X_1=computed straits of Florida surface temperature in—	A=base temperature (° F.)	X_2=air temperature anomaly at Key West, same month	X_3=eastern Gulf of Mexico surface temperature anomaly, same month	X_4=percent of possible sunshine at Key West, same month	X_5=eastern Gulf of Mexico surface temperature anomaly, 1 month earlier
December	77.62	$+0.27X_2$	$+0.17X_3$	$-1.44X_4$	$+0.18X_5$
January	75.97				
February	77.41	$+0.35X_2$	$+0.03X_3$	$-3.21X_4$	$+0.25X_5$
March	77.58				
April	76.73	$+0.28X_2$	$+0.61X_3$	$-0.00X_4$	$+0.10X_5$
May	78.55				
June	81.55				
July	83.44	$+0.09X_2$	$+0.87X_3$	$+0.30X_4$	$+0.14X_5$
August	83.98				
September	84.38	$+0.34X_2$	$+0.60X_3$	$-1.29X_4$	$+0.00X_5$
October	82.36				
November	80.04	$+0.16X_2$	$+0.53X_3$	$-1.85X_4$	$+0.11X_5$

In equation 1, the coefficients, 0.27, 0.17, −1.44, and 0.18, express the separate contributions per unit of variation in the individual factors that seem to influence straits temperature anomalies. These coefficients, while in the most convenient form for computation of the straits temperature, are not in a form to express the relative importance of each factor. For this, the ordinary range of variation, either in degrees or percent of possible amount, may be taken as a unit. On such a basis, the regression coefficients shown in table 1 were multiplied by the standard deviations of the respective X's, and divided by the standard deviation of X_1. The results are the β-coefficients as shown in table 2.[1]

Immediately below the β-coefficients are shown the multiple correlation coefficients computed from the regression equations in table 1. A part of the correlation found was, however, due to the fact that data for only 13½ years were used. The net correlation coefficients, adjusted downward to allow for the short period of time used, are shown in the next line of figures. It will be seen that even these reduced values are uniformly high.

Counting the dual influence of the eastern Gulf anomalies as two independent variables, nearly all of the observed variation in the straits surface water temperature anomalies is therefore reproduced, numerically speaking, by the combined correlation of the values for these four influencing variables with those for the straits water temperatures.

Perfect correlation between these data would not be possible even if no factors other than these four influenced the straits water temperatures. The multiple correlation coefficients found would differ materially from unity (which value would, of course, show exact correspondence or perfect correlation), even if many centuries of data were available. This is because each mean monthly temperature value for the straits surface waters is computed from a limited number of observations, scattered over a considerable area, no two spots of which have mutually homogeneous temperatures. Different ships take the observations on different days. While this gives a nearly random sampling of water temperatures for those portions of the straits area represented by the ship tracks, it does not give an exact mean. There is a difference of several degrees between the highest and the lowest temperatures observed in the area during a month. Therefore, because of random sampling errors alone, actual monthly mean temperatures in the Straits of Florida cannot be determined to a greater degree of precision than to about two-tenths of a degree, Fahrenheit.

It is a mathematical property of correlated variables that if there are random sampling errors in any, several, or all of the variables, such as do exist in the data used, the *computed* correlation between the approximate values will be lower than the *true* correlation between the exact values of the variables. In particular, the actual proportion of explainable but unaccounted-for variation is much less than the difference between the net correlations shown in table 2 and perfect correlation. An approximation to the highest possible amount of correlation which could be found assuming that all influencing factors were included, but using the inexact data available for straits temperature anomaly computations, is shown on the next line of this table (maximum $R_{1\cdot2345\cdots\infty}$).

These are the computed values of the most probable degree of multiple correlation which would be found between straits water temperature anomalies on the one hand and the values of *all* influencing factors, however minute, on the other hand, assuming the hypotheses:

1. That the individual straits temperature values are of the same degree of accuracy, distributed in the same way, and of the same number per month as in the sample period used.
2. That all the values for the assumed infinite number of influencing factors are exactly known.
3. That an infinite number of years' records are available.

Of course, the second and third assumptions are far from true, so that only 1 of 3 important sources of irreducible statistical alienation, namely, the uncertainty in the values of the straits temperature anomalies, has been included. As a mathematical consequence, even if the four influencing factors were the sole causes of fluctuations in X_1, the computed correlation would in few instances be as high as the values shown for maximum $R_{1\cdot2345\cdots\infty}$.

One such exceptional instance exists in the data shown in table 2. The net adjusted multiple correlation coefficient $\overline{R}_{1\cdot2345}$, for July-August, is, 0.970. The theoretical maximum-possible value comes out as 0.964. This slight discrepancy merely indicates that another sample period of 14 years would probably indicate a slightly smaller value for $\overline{R}_{1\cdot2345}$ than that found for the 14 midsummers used, but, for the same reason, if accurate values of the variables were used, the true correlation might well be substantially above 0.990. The theoretical chances of this last possibility are of the order of about 10 to 1 that this value of 0.990 for the true correlation would be exceeded.

The last line of table 2 lists the approximate fractions of the total variation in the Straits of Florida water temperature anomalies which are not accounted for by

[1] Cf. Rietz, Handbook of Mathematical Statistics, pp. 139–140.

the regression equations shown in table 1. The formula for computing these residual fractions is given in the "Remarks" column in table 2. For reasons stated earlier in this paper, the values in table 2 are virtually the maximum limiting values for the residuals, rather than the most probable values, except in the case of the July-August figures, which have been discussed. In spite of the small magnitudes of these residuals, the values shown are therefore very liberal estimates of the proportion of total variations in the straits water temperature anomalies still left to be accounted for. If any fifth, unconsidered, influencing factor be important, its influence on the straits temperature departures from normal, so far as that influence is independent of its association with 1 or more of the 4 factors chosen, must lie within these small residuals shown on the last line of table 2. These residuals are vanishingly small, compared with the irreducible uncertainties in the original data. It follows that the only factors which can be important influences, other than those here included, are such as exert important causative influences on these four factors, and such factors as are acted upon by them.

TABLE 2.—*Beta coefficients, coefficients of multiple correlation, and relative proportions of residual temperature variations left unaccounted for, computed from regression equations shown in table 1*

Remarks	Coefficient	Months					
		Dec.–Jan.	Feb.–Mar.	Apr., May, June	July–Aug.	Sept.–Oct.	Nov.
X_2=Key West air	$\beta_{13.245}$	+0.812	+0.977	+0.504	+0.116	+0.490	+0.288
X_3=Gulf water	$\beta_{12.345}$	+.181	−.039	+.472	+.768	+.611	+.762
X_4=Key West sunshine.	$\beta_{14.235}$	−.189	−.230	−.0003	+.028	−.178	−.204
X_5=Gulf water (previous month).	$\beta_{15.234}$	+.247	+.263	+.084	+.117	+.003	+.104
Mult. corr. coefficient.	$R_{1.2345}$	.940	.935	.922	.974	.916	.918
$R_{1.2345}$ adjusted to 13–14 years data.	$\overline{R}_{1.2345}$	.928	.923	.912	.970	.900	.880
Upper limit of $\overline{R}$	Max. $\overline{R}_{1.2345\ldots\infty}$	.948	.963	.956	.964	.959	.965
$\sqrt{1-\text{Max. } R^2_{1.2345\ldots\infty}}$ $-\sqrt{1-\overline{R}^2_{1.2345}}$	Residual variation.	.056	.114	.117	.000	.151	.213

EXPLANATION.—The β's are indices of the relative importance of the 4 respective influencing factors. The signs show whether the relationship is direct or inverse.

E. g. $\beta_{12.345}$ shows the net relationship between X_1 and X_2, etc.

$R_{1.2345}=\sqrt{1-(1-R^2_{1.2345})\ (n-1/n-m)}$ where n=number of items, and m=number of variables, i. e. 5.

Maximum $\overline{R}_{1.2345\ldots\infty}$=most probable value of $\overline{R}$ if all influencing factors were included in the correlations, and if precise values for these factors were known and used. Its departure from 1.000 therefore measures the effect of using inexact original observational data for determination of X_1.

The residual variation is the maximum probable fraction of the total variation in X_1, remaining to be explained by factors other than, and independent of X_2, X_3, X_4, and X_5.

The average discrepancy between the computed sea-surface temperatures in the Straits of Florida (using the equations from table 1) and the actual temperatures (using monthly means computed directly from the raw data) was about 0.2° F. This discrepancy is relatively, as well as in a practical sense, very small. It is, in fact, almost identical in magnitude with the average uncertainty in actual temperature due to the limited size of the sample from which the monthly mean was computed, and is much less than the probable systematic errors involved in using intake-thermometer and bucket observational material.

Obviously the group of factors here classed under the caption of "Air Temperature" is the most important single influence affecting the Straits temperature anomalies in the winter season. The eastern Gulf of Mexico temperature anomalies are dominantly correlated with the Straits anomalies in summer, though not in winter. Percentage of possible sunshine at Key West is of some importance as an index in winter. The effect of the eastern Gulf of Mexico water temperatures the month before that representing the Straits temperature situation is large enough, in winter, to be probably significant, but this factor, even in winter, is not of great importance when compared with the high degree of correlation between the temperature anomalies of Straits water and Key West air. In summer, only the temperature situations of the current month in the eastern Gulf surface water and in the Key West air seem to have any significant influence.

We may now proceed to consider the data from a less technical statistical viewpoint and touch upon some aspects of the question, How valid are the conclusions herein reached by mathematical statistics?

Throughout the year, but more particularly in the winter, the normal average air temperatures are lower than water temperatures in the Straits of Florida, and the air necessarily exerts a net cooling influence upon the water temperature.

The daily air temperatures at extratropical land stations, even as far south as Key West, may vary at times from their seasonal normals by as much as 15°. The water temperatures in the Straits are seldom as much as 3° warmer or cooler than their seasonal normals, and are continuously and considerably warmer than the air temperatures in the wintertime. It is quite in accord with thermal laws to expect that the large fluctuations in air temperature should influence these small water temperature fluctuations, and this kind of influence affords, not the most ingeniously analytical but the simplest explanation of the major part of the variations in temperature in the northern part of the Straits and of an important part of the temperature variations occurring in the southern subdivision of this area. It is a reasonable assumption, therefore, to attribute the observed correlation between air and water temperatures largely to energy exchanges between the air and water.

One instance of the working of such an exchange of energy between air and water was studied for the cold wave of December 31, 1927, to January 5, 1928. This was the most severe cold wave in the Gulf of Mexico littoral and southern Florida in recent years.

The cold weather first touched the Gulf of Mexico on December 31. By January 2, it had become established over the southern portion of the Florida peninsula. On that day Key West reported a maximum temperature of 59°. The water temperature dropped several degrees along the northwestern fringes of the Gulf on the first and second of the month, the second and third days of the cold wave, and showed a similar drop on the second and third of January over the middle and eastern Gulf. A drop in surface-water temperature, amounting to 2° or 3°, occurred in the waters near Key West on the fourth of January and appeared in the eastern part of the Straits area on the fifth. In general, the time-lag between the onset of low air temperatures and the first appearance of radically lowered surface-water temperatures was from 1 to 3 days.

A similar study was made of the cold wave in March 1932. The Straits of Florida water temperatures fell radically the same week that the cold wave occurred. The evidence of the available bucket and condenser intake-thermometer observations indicate that there is a very strong, direct, and practically immediate cause and effect relationship between air and water temperature variations.

About 80 percent of the observations used in arriving at this conclusion were made by bucket. Nearly all the rest of the available material was from intake ther-

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mometer readings, but a few thermograph records were also available, enough to make a fair-sized check sample.

The conclusions regarding the effects of local air temperature on water-surface temperature in the Straits could, therefore, be checked by comparing the results from bucket and intake-thermometer material with the available thermograph records made while crossing the axis of the Gulf Stream. Forty-two thermograms were examined for this check investigation of the effect of air temperatures upon water temperatures.

It was found that the thermograph records for the area near the Gulf Stream axis showed temperature fluctuations substantially identical in sign and amount with those shown by the bucket and intake thermometer observations over the entire Straits area for the same 42 days as those on which the thermograph records were made. Specifically, for every degree of difference in Key West air temperature, the water temperature anomaly at intake level varied, on the average, by 0.18°, a result which is approximately equivalent to the ratio relationships found between water temperature fluctuations, as indicated by bucket and intake-thermometer readings, and air temperatures (see table 1).

The regression equations point to the eastern Gulf of Mexico water temperature as the next factor in order of importance.

Two kinds of relationship between Straits of Florida surface-water temperature anomalies and anomalies in eastern Gulf of Mexico surface temperatures have been found. The more important, in point of closeness of correlation, is that causing both Straits and Gulf to become warmer or cooler, relative to the seasonal normal, at the same time. This coincidence of temperature variation is very close during the early summer months. At this season of the year, not only the signs of the temperature departures in both areas, but also the sizes of these departures, and the actual temperatures are all nearly identical most of the time.

It seems probable that this condition is due to the fact that water temperatures in both areas simultaneously come under the same modifying external influences and that none of the effects of variations in these external influences are very strong in summer. In the winter season, the degree of correlation between Straits and eastern Gulf surface temperature anomalies in the same month becomes small and unimportant as the influence of the local air temperature conditions becomes more potent.

The second kind of relationship between surface temperatures in the Straits and in the eastern Gulf is one involving a time-lag of about a month. The amount of correlation is highest in winter and spring, and lowest in summer, too low in summer to be of a certainty real. Even in the winter and spring, when the relationship is at its closest, it is still not large enough to be important except as an evidence that a movement of masses of surface water, carrying a water temperature anomaly from one place to another, not too far distant, appears to take place as a minor influence that affects water-surface temperatures in the destination area.

The percentage of possible sunshine at Key West accounts for a large part of the winter variation in Straits water temperatures. The data for the years used in the present study, 1920 to 1933, inclusive, indicate that Key West is likely to have warmer weather in months with abnormally large amounts of sunshine than in cloudy months. The Straits water, however, is no warmer in winters with more than normal sunshine than in those with less than normal. But, since on the average, the higher the air temperature, the higher the water temperature, paradoxically the net residual effect on the water temperature of weather with a high percentage of sunshine is cooling. The same reasoning applies to a month with less sunshine than normal. Cloudy weather tends to produce, after allowing for cooling by consequent lower air temperature, warmer surface water in the Straits than would be there if the amount of sunshine were normal.

We cannot with reason suppose that the mechanism back of this effect is direct, and that increased insolation produces lower water temperatures, because sunshine is a direct and primary source of heat in any marine area. The inverse net relationship between amount of sunshine and water temperature is prominent only in the winter, and we may suppose that perhaps differences in net radiation of heat to space under a clear and under a cloudy sky might be involved. The physical explanation is obscure; the existence of the inverse relationship is fairly certain, whatever the cause; and it is proper to include the percentage of possible sunshine as one of the variables whose fluctuations tend strongly to coincide (inversely in this case) with variations in Straits water temperature in winter.

The most important of the minor factors influencing water surface temperature variations from seasonal normal in the Straits, among those not included in these equations, is the effect of variations in the temperature anomalies in the Caribbean Sea. It is the most important because the most attention in studies of sea-surface temperature variations has hitherto been given to this Caribbean influence. The prominence which has been attached to this possible source of surface temperature influence led, in the Weather Bureau project of water temperature investigation, to the expenditure of great labor in applying every reasonable statistical device to detect, if possible, the "carry-through" of temperature variations from Caribbean to Straits, and to measure the relative significance of this temperature variation cargo as a causative influence modifying the Gulf Stream surface temperature.

It has been readily possible to trace the "carry-through" of temperature anomaly from the Caribbean to the Florida Straits during some seasons, just as it has been possible to show a "carry-through" of surface temperature from eastern Gulf to the Straits. The Caribbean surface temperature fluctuations, even in summer, account, however, for no substantial fraction of the warming and cooling which takes place in the Gulf Stream water while this water is in the Straits of Florida. It is true that in summer the Caribbean Sea surface correlates closely in temperature with the Straits surface water, and high or low temperatures tend strongly to occur together in the two areas; but during the period of record, abnormal temperatures have been found in a slight majority of cases earlier in the Straits than at the source of the water in the Caribbean. Hence no dominant or even important direct flow relation seems to exist between these areas insofar as temperature variations are concerned, and the Caribbean water assumes a role of accounting for most of the high temperature of the Straits surface waters, but for little of its temperature variation.

Because the discrepancies between computed and actual temperatures in the Straits (arrived at without use of a Caribbean factor) are scarcely larger than are the uncertainties of the raw data—that is, the actual temperatures—we may conclude that the Straits temperature variations about the normal are dominantly controlled by contemporary and local, or practically local, influencing factors. The only noncontemporary influence, that

of the eastern Gulf temperatures 1 month earlier, is minor at all seasons.

Among the corollaries of this conclusion are:

(1) Since nearly all the variation in the Straits temperatures shown in the data available can be explained in terms of normal seasonal march of temperature plus the influence of contemporary conditions in areas nearby, there is no important residual variation requiring for its explanation the operation of related conditions in far distant localities.

(2) It follows that until the future sequence of air temperatures, the future number of hours the sun will shine in the Straits area, or the future temperature of the surface waters in the eastern Gulf of Mexico can be independently predicted, the future sequence of the water-surface temperatures in the Straits of Florida must remain unpredictable.

(3) Consequently, the possibility of ever showing that Caribbean sea-surface temperature variations dominate the variations in Gulf Stream water-surface temperatures in the Straits of Florida, would seem to be approximately zero.

(4) Admittedly further study may perhaps show that important influences exist upon Straits water temperature departures from normal, besides those here shown to be significant. If they do, they are, as has been pointed out, also highly correlated with one or more of the factors already found, since the combined independent influence of any further modifying factors cannot account for a larger fraction of the Straits temperature fluctuations about seasonal normal than is approximately shown in the last line of table 2.

Therefore, in a superficial sense at least, the numerical relationships between the causes back of the Straits temperature fluctuations are so closely given by the regression equations shown in table 1 that, from the numerical values of the four related factors here discussed, we can compute the Straits average surface temperature for any month almost as accurately as it can be found by actually averaging all the available temperature readings made during that month.

Let it be here repeated, that the temperature variation in the Caribbean Sea is not one of the four factors found in this study to be quantitatively significant in influencing Straits of Florida surface temperature variations from seasonal normal.

It appears, therefore, that predictable water-surface temperature anomalies are not transmitted by any simple, stream-like flow of water from one place to another for any great distance in the regions at the origins of the Gulf Stream. There can be little hope, therefore, of establishing the fact of such a transmission of temperature variation along any other part of the Gulf Stream or along any extratropical route other than the Gulf Stream, since it must be admitted by all that the region out of which the Gulf Stream arises is the most favorable region in which to expect comparatively undisturbed transmission of temperature-variation-cargo from torrid to temperate latitudes.

BIBLIOGRAPHY

C. FITZHUGH TALMAN, *in charge of Library*

RECENT ADDITIONS

The following have been selected from among the titles of books recently received as representing those most likely to be useful to Weather Bureau officials in their meteorological work and studies:

Rohrbeck, Walther

Die Schätzungsgrundlagen bei Hagelschäden, von Walther Rohrbeck und Dr. Otto Schlumberger. Berlin: P. Parey, 1933. 36 p. xv pl. on 8 l. 21½ cm. "Schriftennachweis": p. 34–36.

[Smith, W. A., ed.]

A world list of scientific periodicals published in the years 1900–1933. 2d ed. London, Oxford university press: H. Milford, 1934. xiv, 779 p. 27 cm. An alphabetical list of over 36,000 titles, giving the full title, the abbreviated title, the symbols for the libraries filing the periodical, and their holdings. Edited by W. A. Smith. Preface signed: P. Chalmers Mitchell. "Library symbols": p. xiii–xiv. "International congresses": p. 769–[780].

Vallaux, Camille

Géographie générale des mers, avec 114 figures et dessins de l'auteur en texte, 16 planches de photogravures et 4 cartes hors texte. Paris: F. Alcan, 1933. vii, 795 p. illus., plates, fold. maps, diagrs. 25 cm.

SOLAR OBSERVATIONS

SOLAR RADIATION MEASUREMENTS DURING NOVEMBER 1934

By IRVING F. HAND, Assistant in Solar Radiation Investigations

For a description of instruments employed and their exposures, the reader is referred to the January 1932 REVIEW, page 26.

Table 1 shows that solar radiation intensities averaged above normal for November at Washington and slightly below at Madison and Lincoln.

Table 2 shows a deficiency in the amount of total solar and sky radiation received on a horizontal surface at all stations for which normals have been computed.

It is interesting to note from table 3 the rapid increase in water vapor toward noon on both November 2 and 5. On both of these days clouds formed shortly after noon. On the other hand, the 9th and 15th show in general diminished water-vapor content with approach of high sun. The 17th shows little dust and low water content of the atmosphere.

Polarization measurements obtained on 5 days at Washington give a mean of 59 percent with a maximum of 68 percent on the 15th. At Madison measurements made on 4 days give a mean of 53 percent with a maximum of 57 percent on the 6th. All these readings are below the November normals.

TABLE 1.—*Solar radiation intensities during November 1934*

[Gram-calories per minute per square centimeter of normal surface]

WASHINGTON, D. C.

Date	Sun's zenith distance: 8 a.m.	78.7°	75.7°	70.7°	60.0°	0.0°	60.0°	70.7°	75.7°	78.7°	Noon
	75th mer. time	Air mass: A. M.					P. M.				Local mean solar time
	e	5.0	4.0	3.0	2.0	*1.0	2.0	3.0	4.0	5.0	e
	mm	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal*	*mm*
Nov. 1	9.83					1.58	1.33	1.10			3.15
Nov. 2	3.99	0.90	1.00	1.14	1.37						2.49
Nov. 5	7.04	.77	.90	1.09							6.50
Nov. 7	4.57					1.33	1.18	.95	0.77		5.16
Nov. 9	3.30	1.01	1.12	1.26	1.39	1.58	1.40	1.20	1.04	0.94	3.00
Nov. 15	2.49	.97	1.09	1.21	1.37		1.38	1.06			2.87
Nov. 17	3.99	.76	.89	1.01	1.24						4.75
Means		.88	1.00	1.14	1.34	1.50	1.32	1.08	(.90)	(.94)	
Departures		+.11	+.13	+.13	+.15	+.02	+.14	+.08	+.15	+.20	

MADISON, WIS.

Nov. 1	3.00						1.36				2.74
Nov. 5	6.27			1.19	1.37		1.34				5.36
Nov. 7	4.75	1.00									4.75
Nov. 8	3.81	1.00	1.17	1.28							3.15
Nov. 12	3.15	.73									3.15
Nov. 13	4.95	1.00	1.12								3.81
Nov. 15	3.63	.87	.98				1.24	0.96			4.17
Nov. 16	5.16	.57	.66		1.16		1.11	.86			8.18
Nov. 24	3.63		.45								3.99
Means		.86	.88	(1.24)	(1.26)		1.26	(.91)			
Departures		−.02	−.13	+.08	−.04		−.06	−.21			

* Extrapolated.

TABLE 1.—*Solar radiation intensities during November 1934*—Con.

[Gram-calories per minute per square centimeter of normal surface]

LINCOLN, NEBR.

Date	Sun's zenith distance: 8 a.m.	78.7°	75.7°	70.7°	60.0°	0.0°	60.0°	70.7°	75.7°	78.7°	Noon
	75th mer. time	Air mass: A. M.					P. M.				Local mean solar time
	e	5.0	4.0	3.0	2.0	1.0	2.0	3.0	4.0	5.0	e
	mm	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*mm*
Nov. 2	3.15						1.12	0.85	0.69	0.56	4.47
Nov. 5	13.39				1.43		1.41				4.17
Nov. 6	14.10	0.88	1.01	1.16	1.40		1.38	1.22	1.08	.99	7.04
Nov. 7	5.56	.87	.92	1.11	1.39						7.04
Nov. 8	4.37	.95	1.06	1.23	1.37			1.21	1.07	.96	4.57
Nov. 10	3.81	.92									3.50
Nov. 12	3.63	.78	.94	1.10	1.30		1.30	1.12	.94	.78	4.70
Nov. 13	4.37						1.37	1.16	1.05	.97	5.16
Nov. 14	3.81	1.05	1.15	1.27	1.42		1.43	1.28	1.10	1.01	4.17
Nov. 15	4.57	.78	.88	1.08	1.32						7.29
Nov. 17	10.21						1.26				11.38
Nov. 22	2.49				1.47			1.27	1.14	1.02	2.26
Nov. 23	3.30		.96	1.10				1.20	1.00	.94	4.57
Means		.89	.99	1.15	1.39		1.32	1.16	1.01	.90	
Departures		−.01	−.03	−.02	+.04		−.03	−.02	−.03	−.02	

BLUE HILL, MASS.

Nov. 2	2.4			1.18	1.36		1.33				1.9
Nov. 3	3.3						1.25	1.12			2.9
Nov. 5	10.0			1.13	1.21						9.3
Nov. 7	3.8			1.22	1.33						4.2
Nov. 8	4.6	1.03	1.09	1.14	1.27		1.24	1.06			3.8
Nov. 9	4.2	1.09	1.23	1.30	1.39		1.30	1.20			3.2
Nov. 12	4.0				1.28		1.23				3.6
Nov. 13	2.9				1.27						3.2
Nov. 14	3.0		1.04	1.25	1.36		1.37	1.10			2.3
Nov. 15	2.5	1.21	1.27	1.33	1.29		1.29				2.4
Nov. 17	4.2	.95	.96	.97	1.03		1.03	1.00			6.3
Nov. 25	3.0	1.05	1.14	1.21	1.28						3.1
Means		1.07	1.12	1.19	1.28		1.26	1.10			

TABLE 2.—*Average daily totals of solar radiation (direct+diffuse) received on a horizontal surface*

Week beginning—	Gram-calories per square centimeter: Washington	Madison	Lincoln	Chicago	New York	Fresno	Pittsburgh	Fairbanks	Twin Falls	Miami	New Orleans	Riverside	Blue Hill	Mount Washington	Friday Harbor
1934	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*
Oct. 29	275	194	246	175	162	315	153	41	210	346	294	295	233		81
Nov. 5	206	187	281	181	160	296	106	28	281	335	322	308	212		117
Nov. 12	232	159	182	170	133	180	142	34	208	320	285	213	232		112
Nov. 19	197	88	147	160	144	177	86	40	131	330	190	292	156		77
Nov. 26	97	69	70	55	65	215	101	8	176	284	160	289	117		84
	Departures from weekly normals														
Oct. 29	+24	+8	+5	+29	−20	−8	−1	+3	−30	±0	+14				
Nov. 5	−21	+22	+37	+58	+12	+5	−22	−1	+77	−7	+46				
Nov. 12	+33	+21	−29	+67	+6	−79	+21	+9	+33	−28	+26				
Nov. 19	+9	−39	−60	+45	+23	−59	−35	−19	−26	+6	−38				
Nov. 26	−70	−56	−117	−31	−42	+2	−5	−6	+36	−14	−54				
	Accumulated departures on Dec. 2														
	+2,198	−3,262	+6,071		+13,379	+8,491	+603	+455	+5,845	−7,763	+6,224				

TABLE 3.—*Total, I_m, and screened, I_y, I_r, solar radiation intensity measurements, obtained during November 1934, and determinations of the atmospheric turbidity factor, β, and water-vapor content, w=depth in millimeters, if precipitated*

AMERICAN UNIVERSITY, WASHINGTON, D. C.

Date and hour angle	Solar altitude	Air mass	I_m	I_y	I_r	β_{1m-r}	β_{1y-r}	β_{m-ca}	$\frac{I_{m-r}}{1.94}$	$\frac{I_{y-r}-I_m}{1.94}$	w	Air-mass type
									percentage of solar constant			
Nov. 2, 1934	° ′	*m*	*gr. cal.*	*gr. cal.*	*gr. cal.*						*mm*	
3:52 a. m.	13 53	4.12	1.010	0.792	0.661	0.044	0.046	0.045	59.8	8.4	1.7	P_c
3:47 a. m.	14 41	3.89	1.024	.794	.661	.042	.046	.044	61.2	9.2	2.7	
3:32 a. m.	17 03	3.38	1.090	.853	.646	.025	.018	.022	71.5	16.2	47.8	
3:26 a. m.	17 58	3.22	1.120	.855	.646	.020	.020	.020	73.8	16.9	52.5	
Nov. 5, 1934												
3:52 a. m.	13 14	4.30	.857	.704	.586	.072	.060	.066	55.0	11.6	6.9	N_{rr}
3:48 a. m.	13 53	4.12	.876	.766	.588	.070	.072	.066	54.8	10.4	4.7	
3:36 a. m.	15 47	3.64	.926	.724	.605	.068	.068	.068	56.6	9.7	3.6	
3:32 a. m.	16 24	3.51	.952	.726	.608	.065	.075	.070	56.8	8.6	2.3	
3:28 a. m.	17 02	3.39	.966	.746	.611	.052	.060	.056	61.2	12.3	11.5	
2:46 a. m.	23 01	2.55	1.063	.750	.647	.042	.070	.056	65.2	11.3	10.3	
2:42 a. m.	23 45	2.48	1.092	.809	.647	.034	.054	.044	71.4	16.0	60.0	
Nov. 9, 1934												
3:46 a. m.	13 16	4.30	1.008	.869	.694	.022	.010	.016	69.8	14.2	17.5	P_c
3:41 a. m.	14 02	4.08	1.125	.872	.697	.020	.014	.017	69.4	12.4	9.9	
3:33 a. m.	15 16	3.76	1.182	.872	.716	.018	.028	.023	69.6	9.7	3.5	
3:30 a. m.	15 48	3.64	1.180	.876	.719	.020	.026	.023	70.0	10.2	4.3	
3:13 a. m.	18 16	3.17	1.232	.940	.757	.020	.020	.020	74.0	11.6	9.3	
3:09 a. m.	18 52	3.07	1.277	.943	.759	.018	.018	.018	74.0	9.3	3.6	
3:01 a. m.	20 00	2.90	1.262	.952	.778	.028	.028	.028	71.8	6.8	1.3	
2:57 a. m.	20 33	2.83	1.298	.955	.780	.022	.026	.024	71.8	6.0	.9	
2:31 a. m.	24 00	2.45	1.313	.963	.787	.028	.038	.033	75.0	8.4	3.0	
2:27 a. m.	24 33	2.40	1.329	.965	.790	.028	.042	.035	75.0	7.6	2.2	
1:44 a. m.	29 14	2.04	1.410	.985	.790	.018	.032	.025	79.3	7.8	2.8	
1:41 a. m.	29 28	2.02	1.383	.989	.790	.020	.032	.026	79.2	9.0	4.7	
0:25 a. m.	33 59	1.79	1.430	1.008	.805	.021	.033	.027	80.4	7.8	3.1	
0:20 a. m.	34 05	1.78	1.451	1.010	.805	.018	.032	.025	81.2	7.5	2.8	
Nov. 15, 1934												
3:36 a. m.	13 36	4.20	1.048	.846	.678	.044	.018	.031	64.6	11.6	7.0	P_c
3:32 a. m.	14 14	4.02	1.089	.846	.679	.022	.022	.022	68.2	13.1	12.7	
2:59 a. m.	19 02	3.05	1.188	.928	.729	.032	.010	.026	71.8	11.7	10.1	
2:55 a. m.	19 32	2.98	1.218	.930	.732	.024	.010	.017	76.4	14.8	35.1	
2:18 a. m.	24 10	2.43	1.330	.967	.783	.022	.034	.028	74.8	7.4	2.0	
2:14 a. m.	24 42	2.38	1.333	.970	.785	.023	.036	.030	75.0	7.4	2.0	
1:17 a. m.	29 57	2.00	1.367	.991	.801	.032	.040	.036	76.8	7.5	2.5	
1:02 a. m.	30 52	1.95	1.389	1.005	.802	.028	.024	.026	79.5	9.0	4.9	
0:58 a. m.	31 08	1.93	1.392	1.010	.800	.028	.022	.025	79.6	9.0	4.9	
0:15 a. m.	32 34	1.86	1.392	.984	.777	.020	.024	.022	81.6	11.0	12.4	
0:11 a. m.	32 37	1.85	1.408	.984	.777	.018	.024	.021	81.6	10.2	8.5	
Nov. 17, 1934												
3:41 a. m.	13 11	4.32	.836	.683	.581	.078	.070	.074	50.6	8.3	1.6	N_{rc}
3:37 a. m.	13 48	4.14	.852	.683	.581	.076	.076	.076	51.2	8.1	1.5	

Atmospheric conditions during turbidity measurements

Nov. 2: Temperature, 2° C.; wind, NW. 12; visibility, 20 miles; polarization, 50 percent; blueness of sky, 4.
Nov. 5: Temperature, 7° C.; wind, NW. 16; visibility, 20 miles; polarization, 64 percent; blueness of sky, 5.
Nov. 9: Temperature, 2° C.; wind, N. 15; visibility, 50 miles; polarization, 66 percent; blueness of sky, 6.
Nov. 15: Temperature, −2° C.; wind, NW. 10; visibility, 30 miles; polarization, 68 percent; blueness of sky, 6.
Nov. 17: Temperature, 0° C.; wind, S. 8; visibility, 12 miles; polarization, 47 percent; blueness of sky, 4.

TABLE 3.—*Total, I_m, and screened, I_y, I_r, solar radiation intensity measurements, obtained during November 1934, and determinations of the atmospheric turbidity factor, β, and water-vapor content, w=depth in millimeters, if precipitated*—Continued

BLUE HILL METEOROLOGICAL OBSERVATORY OF HARVARD UNIVERSITY

Date and hour angle	Solar altitude	Air mass	I_m	I_y	I_r	β_{1m-r}	β_{1y-r}	β_{mean}	$\frac{I_{y-c}}{1.94}$	$\frac{I_{y-c}-I_m}{1.94}$	w	Air-mass type
									percentage of solar constant			
Nov. 2, 1934	° ′	*m*	*gr. cal.*	*gr. cal.*	*gr. cal.*						*mm*	
2:24 a. m.	24 10	2.43	1.373	1.004	0.820	0.026	0.037	0.032	80.7	11.1	10.1	P_c
2:11 a. m.	25 36	2.31	1.382	1.018	.820	.026	.021	.024	77.7	7.5	2.1	
0:43 p. m.	32 11	1.87	1.388	.988	.803	.036	.054	.045	77.4	7.0	2.2	P_c
1:59 p. m.	27 12	2.18	1.282	.945	.766	.048	.049	.048	72.7	7.7	2.5	
Nov. 3, 1934												
0:59 a. m.	31 11	1.93	1.240	.903	.724	.060	.075	.068	72.3	9.4	6.1	N_{Pc} and P_c
0:30 p. m.	32 22	1.87	1.223	.891	.716	.069	.073	.071	71.2	9.2	5.5	P_c and N_{Pc}
Nov. 5, 1934												
2:24 a. m.	23 21	2.52	1.166	.850	.694	.047	.065	.056	68.0	8.9	3.8	N_{rr}
1:11 a. m.	29 55	2.00	1.205	.881	.703	.060	.056	.058	72.4	11.3	11.3	
0:37 p. m.	31 33	1.91	1.191	.864	.679	.060	.050	.055	72.0	11.6	16.0	T_a aloft
Nov. 7, 1934												
3:21 a. m.	15 30	3.70	1.210	.894	.744	.018	.038	.028	67.9	6.7	1.1	N_{rr}
Nov. 8, 1934												
3:39 a. m.	12 39	4.50	1.067	.820	.679	.052	.036	.044	68.3	14.3	19.5	P_r
1:55 p. m.	25 34	2.31	1.176	.875	.713	.049	.059	.054	70.3	10.8	9.3	
Nov. 9, 1934												
1:02 a. m.	29 17	2.04	1.388	1.016	.820	.037	.032	.034	77.3	7.1	2.0	P_c
0:19 p. m.	30 49	1.95	1.344	.984	.787	.043	.033	.038	76.6	8.7	4.2	
Nov. 12, 1934												
0:17 a. m.	30 00	2.00	1.283	.928	.749	.049	.058	.054	73.2	8.4	3.7	P_c
Nov. 13, 1934												
1:35 a. m.	25 59	2.28	1.266	.906	.755	.046	.072	.059	69.5	5.6	.9	P_c, N_{rr} aloft
Nov. 14, 1934												
3:24 a. m.	12 41	4.47	1.003	.772	.659	.043	.073	.058	54.8	4.1	.2	P_c
1:59 a. m.	23 44	2.48	1.220	.920	.740	.050	.038	.044	71.2	9.7	5.2	
0:52 a. m.	28 25	2.10	1.305	.982	.795	.045	.045	.045	74.2	6.4	1.5	
0:08 p. m.	29 35	2.02	1.337	.996	.809	.041	.046	.044	75.3	7.4	2.3	P_c
Nov. 15, 1934												
1:38 a. m.	25 30	2.32	1.329	.973	.779	.030	.037	.034	75.1	8.1	2.8	N_{Pc}
0:34 p. m.	28 50	2.07	1.288	.930	.756	.047	.063	.055	72.2	7.3	2.2	P_c
1:58 p. m.	23 31	2.50	1.044	.777	.655	.087	.125	.106	59.2	6.6	1.4	
Nov. 17, 1934												
3:24 a. m.	12 52	4.51	.853	.671	.565	.052	.067	.060	54.1	11.2	5.4	P_{Pc}
2:07 a. m.	22 11	2.63	.987	.742	.596	.075	.073	.074	63.2	13.5	22.8	
0:03 a. m.	28 50	2.07	1.029	.791	.626	.112	.071	.092	65.1	13.3	27.1	
1:58 p. m.	23 03	2.55	1.014	.760	.613	.075	.152	.114	66.3	15.2	53.6	N_{Pc}
Nov. 25, 1934												
3:20 a. m.	11 59	4.72	1.106	.836	.692	.017	.025	.021	65.8	10.3	14.0	P_c
1:13 a. m.	24 47	2.37	1.257	.935	.756	.047	.043	.045	71.9	8.8	3.8	
0:01 a. m.	27 04	2.19	1.260	.921	.743	.048	.051	.050	72.1	8.9	4.3	

Atmospheric conditions during solar radiation measurements, Blue Hill Meteorological Observatory of Harvard University

Date and time	Air temperature	Wind (Beaufort scale)	Visibility; scale 0–10	Sky blueness	Cloudiness and remarks
November 1934	°C.				
2; 1:52 p. m.	3.8	W 5	9+	12?	6 Cu, Frcu.
2; 3:49 p. m.	3.3	W 5	9+	8	1 Cu.
3; 2:25 a. m.	2.8	W 5	8–9	5	7 Ci.
3; 1:09 a. m.	6.1	WSW 1	9−	8	6 Ci.
3; 0:19 p. m.	8.1	SSW 3	8+	8	1 Ci.
3; 3:13 p. m.	9.9	SSW 5	8+	6	Cloudless, haze.
3; 3:53 p. m.	8.9	SE 4	9	5	1 Ci.
5; 2:37 a. m.	11.2	WSW 1	7+	11?	Few Stcu below observatory, few Acu or Ci.
5; 1:20 a. m.	13.8	WNW 1	8−	7	Few Acu, few Ci, haze.
5; 0:28 p. m.	16.8	S 1	8+	7	1 Acu in W, few Frcu, haze.
5; 2:52 p. m.	19.1	S 2	8−	9	2 Cu.
7; 3:31 a. m.	3.3	W 5	9+	9	1 Acu, mod. haze.
9; 3:51 a. m.	3.3	W 5	8	8	Cloudless, mod -dense haze.
9; 1:13 a. m.	6.6	NW 5	9	10	2 Cu, lt. haze.
9; 0:10 p. m.	7.8	NW 5		11?	4 Cu.
9; 3:26 p. m.	7.2	W 4	9	9	Few Cu.
12; 0:25 a. m.	3.3	WNW 5	8+	11?	4 Cu.
13; 1:26 a. m.	2.5	W 6	8	6	2 Cist, 1 Acu, Few Cu, mod. haze
13; 1:15 a. m.	3.0				
14; 3:39 a. m.	−1.7	NNW 4	7	6–7	Few Cu, Stcu.
14; 2:08 a. m.	−2.2	NW 3	9	7	1 Stcu, Cu, few Frcu, smoke NE
14; 0:01 p. m.	−1.7	NW 4	9+	7	1 Stcu in E, few Cu, Frcu, in S, W.
14; 2:17 p. m.	−1.2	NW 4	9+	7	1 Cicu.
15; 3:45 a. m.	−6.4	W 2	9	7	Mod. haze.
15; 0:25 p. m.	+1.2	W 2	8+9		2 Ci, 1 Acu, lt. haze.
15; 1:53 p. m.	3.2	WSW 3	8+9		Few Ci, 3 Acu.
17; 2:15 a. m.	5.6	SW x W 4	7+	6	Few Ci.
17; 0:08 a. m.	11.2	WSW 5	7+	6	Dense haze.
17; 1:49 p. m.	14.4	WSW 4	7+	6	Cloudless, dense haze.
17; 3:41 p. m.	13.8	SW x W 4	8	5	1 Ci, dense haze.
22; 3:23 p. m.	12.7	S 4	9	8	4 Cu.
24; 3:28 p. m.	6.6	NW 4	9	5	6 Ci, 2 Acu, clouds 5° from sun.
25; 3:28 a. m.	−2.7	NNW 5	8	9	Few Acu.
25; 1:17 a. m.	−0.4	N 5	8–9	8	Stcu to E.
25; 0:02 a. m.	+1.1	N 3	8	9	Few Cu.
25; 3:26 p. m.	2.2	N 3	9	9	Few Cu.

POSITIONS AND AREAS OF SUN SPOTS

NOTE.—Owing to delay in receiving the reports for November, the data for that month will be published in the December REVIEW.—Editor.

PROVISIONAL SUN-SPOT RELATIVE NUMBERS FOR NOVEMBER 1934

(Dependent alone on observations at Zurich and its station at Arosa)

[Data furnished through the courtesy of Prof. W. Brunner, Eidgen. Sternwarte, Zurich, Switzerland]

November 1934	Relative numbers	November 1934	Relative numbers	November 1934	Relative numbers
1	13	11	7	21	0
2	14	12	7	22	0
3	16	13	0	23	0
4	14	14	0	24	0
5	12	15	0	25	7
6		16	0	26 *Mc*	11
7	10	17	0	27	14
8	8	18	7	28	23
9	10	19		29 *We*	36
10	7	20	0	30	32

Mean, 28 days=8.9.

c=New formation of a center of activity: E, on the eastern part of the sun's disk; W, on the western part; M, in the central circle zone.

AEROLOGICAL OBSERVATIONS

[Aerological Division, D. M. LITTLE, in charge]

By L. T. SAMUELS

Free-air temperatures for November averaged lowest over Spokane and Fargo and highest over San Diego. (See table 1.) While Fort Crockett appears to average a little higher than San Diego, the former station's means are based on only six observations and are therefore unreliable. Departures from the monthly means at those stations having a sufficiently long record for establishing normals were positive, except at Pensacola and San Diego. The largest departures occurred at Omaha.

Free-air relative humidities averaged highest over Spokane and lowest over San Diego and Kelly Field.

Free-air resultant wind directions were close to normal at practically all stations. (See table 2.) The largest deviations occurred at the western stations where greater than normal westerly components prevailed. Resultant velocities for the month were greatly in excess of the normal along the Pacific Coast and moderately below normal over the southeastern section of the country.

TABLE 1.—*Free-air temperatures and relative humidities obtained by airplanes during November 1934*

TEMPERATURE (° C.)

Stations	Altitude (meters) m. s. l.															
	Surface		500		1,000		1,500		2,000		2,500		3,000		4,000		5,000	
	Mean	Departure from normal	Mean	Departure from normal	Mean	Departure from normal	Mean	Departure from normal	Mean	Departure from normal	Mean	Departure from normal	Mean	Departure from normal	Mean	Departure from normal	Mean	Departure from normal
Billings, Mont.[1] (1,090 m.)	2.3						6.6		5.1		1.8		−2.0		−9.3		−16.1	
Boston, Mass.[2] (6 m.)	5.5		5.0		2.6		1.6		0.0		−1.6		−4.0		−8.9		−15.7	
Cheyenne, Wyo.[1] (1,873 m.)	−.4								2.0		3.0		−.3		−7.0		−13.7	
Fargo, N. Dak.[1] (274 m.)	−1.3		.2		1.2		1.3		0.0		−2.6		−5.5		−11.7		−18.3	
Fort Crockett (Galveston), Tex.[3] (3 m.)	18.0		18.4		16.6		14.8		13.1		10.4		8.0		2.1		−4.9	
Kelly Field (San Antonio), Tex.[3] (211 m.)	13.1		15.9		15.6		13.3		10.9		8.6		6.1		−.2		−7.1	
Lakehurst, N. J.[4] (3 m.)	5.5		6.7		4.4		3.2		1.7		−.7		−2.5		−8.1		−14.8	
Maxwell Field (Montgomery), Ala.[3] (52 m.)	9.3		13.5		12.3		11.4		9.6		7.1		4.9		−.6		−6.9	
Mitchel Field (Hempstead, L. I.), N. Y.[3] (29 m.)	6.2		6.8		4.4		2.3		.3		−1.8		−4.4		−11.7		−18.2	
Murfreesboro, Tenn.[1] (174 m.)	7.2		9.3		8.8		7.4		5.9		3.8		1.3		−4.5		−10.9	
Norfolk, Va.[4] (3 m.)	8.6	0.0	9.7	+.7	7.9	+1.0	6.0	+1.1	3.9	+1.0	2.1	+.8	.1	+.5	−5.4	+.3	−12.1	+.3
Oklahoma City, Okla.[1] (391 m.)	9.4		10.2		11.7		9.8		7.3		4.5		2.0		−4.2		−10.9	
Omaha, Nebr.[1] (300 m.)	3.7	(6)	5.5	(6)	6.7	+3.7	6.2	+4.0	4.5	+4.1	2.0	+3.9	−.9	+3.6	−7.0	+3.0	−13.8	+1.8
Pensacola, Fla.[4] (2 m.)	11.5	−1.7	13.7	+.3	12.1	+0.1	10.4	−.1	8.4	−0.5	6.4	−.3	3.9	−0.6	−1.2	−.1	−7.5	−.1
San Diego, Calif.[4] (10 m.)	12.6	−3.7	14.9	−1.7	14.4	−1.8	12.7	−1.2	10.1	−1.3	7.8	−1.1	5.6	−.8	0.2	0.0	−6.5	+.1
Scott Field (Belleville), Ill.[3] (135 m.)	6.0		8.6		7.4		6.3		4.6		2.5		.2		−5.0		−11.4	
Seattle, Wash.[4] (8 m.)	8.8	+.1	8.8	+1.9	6.6	+2.2	3.0	+1.3	−.2	+.6	−2.8	+.5	−5.6	+.3	−11.3	+.1	−18.3	+.1
Selfridge Field (Mount Clemens), Mich.[3] (177 m.)	4.2		6.1		5.0		2.9		.9		−1.1		−3.2		−8.5		−14.4	
Spokane, Wash.[5] (596 m.)	5.9				6.4		5.4		2.8		−.3		−3.3		−9.2		−15.5	
Sunnyvale, Calif.[4] (6 m.)	12.2		12.2		10.7		8.4		6.2		3.7		1.2		−4.6		−11.3	
Washington, D. C.[4] (2 m.)	6.4	+1.0	7.2	+1.8	5.7	+1.6	3.9	+1.4	2.3	+1.4	0.6	+1.0	−1.2	+1.1	−5.8	+1.4	−12.0	+1.4
Wright Field (Dayton), Ohio[3] (244 m.)	5.1		6.5		6.3		4.1		2.5		.5		−2.2		−8.5		−14.8	

RELATIVE HUMIDITY (PERCENT)

Billings, Mont.[1] (1090 m)	63						49		44		46		49		53		55	
Boston, Mass.[2] (6 m.)	83		77		77		69		65		55		52		50		55	
Cheyenne, Wyo.[1] (1873 m.)	59								57		48		48		47		44	
Fargo, N. Dak.[1] (274 m.)	85		78		70		60		54		52		50		51		50	
Fort Crockett (Galveston), Tex.[3] (3 m.)	87		70		48		40		30		24		19		16		15	
Kelly Field (San Antonio), Tex.[3] (211 m.)	87		74		63		57		51		43		33		28		26	
Lakehurst, N. J.[4] (3 m.)	89		80		78		74		68		62		55		50		41	
Maxwell Field (Montgomery), Ala.[3] (52 m.)	87		63		59		47		42		38		34		30		27	
Mitchel Field (Hempstead, L. I.), N. Y.[3] (29 m.)	84		73		72		68		64		55		53		49		47	
Murfreesboro, Tenn.[1] (174 m.)	77		67		65		62		50		43		36		33		33	
Norfolk, Va.[4] (3 m.)	76	+1	68	+3	64	+3	58	+1	54	+1	49	+3	42	+4	34	+3	31	+3
Oklahoma City, Okla.[1] (391 m.)	76		73		63		61		58		56		49		41		41	
Omaha, Nebr.[1] (300 m.)	86	(6)	79	(6)	70	+12	59	+6	54	+4	51	+2	51	+1	51	0	48	+1
Pensacola, Fla.[4] (2 m.)	80	0	63	−9	58	−8	54	−6	50	−4	45	−4	42	−2	30	−7	23	−8
San Diego, Calif.[4] (10 m.)	85	+19	65	+11	53	+11	43	+7	38	+7	33	+5	30	+4	26	+3	26	+4
Scott Field (Belleville), Ill.[3] (135 m.)	80		64		60		53		48		45		43		41		38	
Seattle, Wash.[4] (8 m.)	85	+5	77	0	74	−1	76	+6	74	+11	63	+7	54	+4	47	+5	43	+5
Selfridge Field (Mount Clemens), Mich.[3] (177 m.)	84		71		68		67		60		53		48		43		38	
Spokane, Wash.[5] (596 m.)	86				79		71		71		73		71		64		62	
Sunnyvale, Calif.[4] (6 m.)	84		75		67		57		50		47		40		30		30	
Washington, D. C.[4] (2 m.)	72	−1	63	−1	60	+1	56	0	55	+2	49	+2	44	+3	39	+2	35	+2
Wright Field (Dayton), Ohio[3] (244 m.)	80		73		68		66		61		56		52		52		48	

Observations taken about 5:00 a. m., 75th meridian time, except along the Pacific coast and Hawaii where they are taken about daylight.

[1] Weather Bureau. [2] Massachusetts Institute of Technology. [3] Army. [4] Navy. [5] National Guard.

[6] Surface and 500-meter level departures omitted because of difference in time of day between airplane observations and those of kites upon which the normals are based.

Fort Crockett means based on only 6 observations and Seattle means on only 12 observations.

TABLE 1.—*Free-air temperatures and relative humidities obtained by airplanes during October 1934*—Continued

[Late reports for October 1934]

TEMPERATURE (°C.)

Stations	Altitude (m) m. s. l.																	
	Surface		500		1,000		1,500		2,000		2,500		3,000		4,000		5,000	
	Mean	Departure from normal	Mean	Departure from normal	Mean	Departure from normal	Mean	Departure from normal	Mean	Departure from normal	Mean	Departure from normal	Mean	Departure from normal	Mean	Departure from normal	Mean	Departure from normal
Sunnyvale, Calif.[1] (6 m)	14.4		14.0		15.8		14.7		12.2		8.9		5.6		−1.2		−8.8	

RELATIVE HUMIDITY (PERCENT)

Sunnyvale, Calif.[1] (6 m)	79		73		51		38		32		28		26		23		22	

[1] Navy.

TABLE 2.—*Free-air resultant winds (meters per second) based on pilot-balloon observations made near 7 a. m. (E. S. T.) during November 1934*

[Wind from N=360°, E=90°, etc.]

Altitude (m) m. s. l.	Albuquerque, N. Mex. (1,554 m)		Atlanta, Ga. (309 m)		Bismarck, N. Dak. (518 m)		Brownsville, Tex. (7 m)		Burlington, Vt. (132 m)		Cheyenne, Wyo. (1,873 m)		Chicago, Ill. (192 m)		Cleveland, Ohio (245 m)		Dallas, Tex. (154 m)		Havre, Mont. (762 m)		Jacksonville, Fla. (14 m)		Key West, Fla. (11 m)	
	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity
	°		°		°		°		°		°		°		°		°		°		°		°	
Surface	356	1.9	303	0.9	9	1.0	122	0.2	192	2.5	285	4.8	232	1.5	195	2.4	149	1.5	272	1.5	338	1.2	54	3.4
500			293	2.3			140	5.5	199	6.5			244	6.1	234	6.2	206	4.8			34	2.2	56	7.0
1,000			292	4.5	289	4.9	158	5.1	224	6.5			252	9.2	240	8.2	225	5.8	245	5.2	192	.9	82	5.1
1,500			287	5.4	294	7.1	179	4.2	245	8.4			269	9.6	243	11.4	252	4.5	262	10.0	259	2.5	79	3.2
2,000	306	2.3	286	6.7	299	8.4	200	3.5	264	8.1	286	7.0	288	9.8	257	10.5	279	4.7	264	10.9	283	3.1	57	2.4
2,500	289	4.0	293	7.3	296	8.9	213	2.6			295	10.0	297	10.8	264	10.8	285	5.3	270	10.8	282	3.6	350	1.7
3,000	287	5.6	292	8.0	295	8.9	233	2.6			297	10.3	292	12.4	274	11.5	277	8.7	277	11.5	276	4.4	298	1.7
4,000	287	8.4	301	7.8	309	11.3	261	1.8			296	8.3			274	13.6	285	6.2	295	11.3	281	5.7	269	4.9
5,000	252	5.3					261	3.3			270	4.1					300	6.2			289	13.1	270	2.2

Altitude (m) m. s. l.	Los Angeles, Calif. (217 m)		Medford, Oreg. (410 m)		Memphis, Tenn. (83 m)		New Orleans, La. (19 m)		Oakland, Calif. (8 m)		Oklahoma City, Okla. (402 m)		Omaha, Nebr. (306 m)		Phoenix, Ariz. (338 m)		Salt Lake City, Utah (1,294 m)		Sault Ste. Marie, Mich. (198 m)		Seattle, Wash. (14 m)		Washington, D. C. (10 m)	
	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity
	°		°		°		°		°		°		°		°		°		°		°		°	
Surface	340	1.2	262	0.4	181	1.5	71	1.8	152	0.6	182	1.4	137	1.1	102	1.7	151	3.5	41	0.9	177	2.5	298	1.3
500	347	1.2	122	.5	208	4.3	142	2.9	267	1.2	190	4.7	211	1.6	98	2.2			319	.5	193	8.1	291	5.8
1,000	343	1.6	170	2.9	252	5.2	216	1.4	298	3.5	228	7.7	246	5.0	66	.7			335	4.3	208	8.3	291	5.1
1,500	344	3.1	202	5.3	254	5.2	266	2.0	292	4.9	250	6.9	251	6.6	107	.7	167	5.5	317	4.8	226	8.9	297	8.2
2,000	339	5.5	219	7.3	293	6.3	304	2.1	307	7.5	264	8.1	298	8.7	223	1.5	183	3.8	335	8.5	229	8.0	291	9.1
2,500	323	6.3	226	10.2	289	6.2	315	3.4	320	9.7	274	6.6	306	11.0	251	2.7	235	2.9	323	9.6	222	8.5	280	8.6
3,000	323	6.6	236	9.4	277	9.6	295	4.5	292	10.2	286	5.1	308	11.4	269	4.3	250	5.7					296	8.6
4,000	296	5.1	242	12.3			5	4.8			319	7.4			286	6.7	259	8.3						
5,000															293	11.2	245	7.1						

RIVERS AND FLOODS

[River and Flood Division, MONTROSE W. HAYES, in charge]

By RICHMOND T. ZOCH

During November there was an important flood in the Grand River in Missouri. This flood was caused by heavy rains during the period of November 17–22. The rainfall was so distributed and timed that the greatest effects of the ensuing flood were concentrated at Chillicothe. Damage exceeding $1,000,000 resulted.

The remaining floods shown in the accompanying table were of minor importance; however, slight damage was caused by the flood in the Pascagoula River.

Heavy rains on the Atlantic slope at the end of November caused floods in several of the rivers of Virginia and North Carolina. As the crests of these rises occurred in December, they will be discussed in a later issue of the MONTHLY WEATHER REVIEW.

Flood stages in November 1934

[All dates are in November unless otherwise specified]

River and station	Flood stage	Above flood stages—dates		Crest	
		From—	To—	Stage	Date
ATLANTIC SLOPE DRAINAGE	*Feet*			*Feet*	
Santee: Rimini, S. C.	12	1	4	13.6	3
		10	11	12.7	11
		16	17	12.6	16
EAST GULF OF MEXICO DRAINAGE					
Tombigbee: Lock No. 3, Ala.	33	24	26	33.8	24, 25
Pascagoula: Merrill, Miss.	22	23	25	22.8	24
Pearl: Jackson, Miss.	18	29	Dec. 2	18.5	Dec. 1
MISSISSIPPI SYSTEM					
Missouri Basin					
Grand:					
Gallatin, Mo.	20	21	23	22.2	23
Chillicothe, Mo.	18	21	24	24.7	23
		29	29	18.5	29
Red Basin					
Sulphur: Ringo Crossing, Tex.	20	21	22	21.5	21
		30	30	20.0	30
Lower Mississippi Basin					
Big Lake Outlet: Manila, Ark.	10	26	(1)	(1)	(1)

[1] Flood continued into December.

WEATHER OF THE ATLANTIC AND PACIFIC OCEANS, NOVEMBER 1934

[The Marine Division, W. E. HURD acting in charge]

NORTH ATLANTIC OCEAN

By H. C. HUNTER

Atmospheric pressure.—The pressure averaged distinctly above the normal over northern portions, notably near the British Isles and in the region of the Canadian Maritime Provinces. Nearer the tropics the pressure averaged below normal, especially round the Azores. In this section the last 8 days of the month were marked by unusually low readings. Turks Island also had low pressure at this time, whereas high pressure was then prevailing near Portugal and Ireland.

The highest pressure reported from a vessel was 30.85 inches, by the British motorship *Cheyenne*, about latitude 46° N., longitude 57° W., during the forenoon of the 27th. On that and the preceding day readings about as high or slightly higher were noted at land stations in the Maritime Provinces. The lowest reading of the month was 28.34 inches, reported by the American steamship *Steelmaker* at an early hour of the 17th, when near 53° N., 45° W., in the area of a well-marked storm moving toward the tip of Greenland.

TABLE 1.—*Averages, departures, and extremes of atmospheric pressure (sea level) at selected stations for the North Atlantic Ocean and its shores, November 1934*

Station	Average pressure	Departure	Highest	Date	Lowest	Date
	Inches	*Inch*	*Inches*		*Inches*	
Julianehaab, Greenland	29.66		30.28	28	28.35	17
Reykjavik, Iceland	29.70	+0.08	30.43	4	29.08	24
Lerwick, Shetland Islands	29.91	+.21	30.36	29	29.44	13
Valencia, Ireland	30.08	+.19	30.54	27	29.26	9
Lisbon, Portugal	30.04	.00	30.42	26	29.58	15
Madeira	30.00	−.01	30.20	13	29.79	1
Horta, Azores	30.03	−.10	30.44	12	29.30	27
Belle Isle, Newfoundland	29.98	+.10	30.64	27	29.40	17
Halifax, Nova Scotia	30.14	+.19	30.86	27	29.34	7
Nantucket	30.13	+.08	30.69	26	29.33	6
Hatteras	30.13	+.02	30.40	16	29.70	7
Bermuda	30.07	−.01	30.36	30	29.42	25
Turks Island	29.93	−.06	30.04	5	29.66	28
Key West	30.03	+.01	30.23	16	29.85	29
New Orleans	30.10	.00	30.40	12	29.66	21

NOTE.—All data based on a. m. observations only, with departures compiled from best available normals related to time of observation, except Hatteras, Key West, Nantucket, and New Orleans, which are 24-hour corrected means.

Cyclones and gales.—During the first few days of the month a storm of considerable strength for the portion of the ocean it covered was located between the Azores and the vicinity of Gibraltar. After several days of slow and irregular movement it turned northeastward over the Bay of Biscay and France on the 4th to 6th.

There were several reports of strong or whole gales near the chief steamship lanes during the first fortnight of the month, particularly over the eastern half from the 8th to 12th.

A storm of moderate energy was noted between Hatteras and Bermuda on the 14th; it gained force rapidly, moving first toward the northeast, but near the fifty-fifth meridian turning its course toward the north-northeast, and reaching the neighborhood of Cape Farewell on the 17th. This storm showed marked strength during the 16th and the early hours of the 17th; two steamers noted readings below 28.50 inches, and a third, the *Braheholm*, reported wind force of 12 from the west. (See charts VIII to X.)

Two storms during the final 11 days of November followed courses so unusual as to be of marked interest. On the evening of the 20th a storm of moderate strength was indicated as central near 25° N., 60° W., whence it advanced northwestward for 3 days, with somewhat increased energy, till about midway between Turks Island and Bermuda. There it turned north-northeastward and on the 25th was central close to, but south of, Bermuda. Thereafter it moved slowly toward the south-southwest, with lessening strength, and was still perceptible on the 29th a short distance southwest of Haiti. No report of any force greater than strong gale (9) has been received in connection with this storm, which was felt most forcefully in the general vicinity of Bermuda.

By the evening of the 21st a LOW of considerable energy was clearly defined near 46° N., 40° W., or a short distance to eastward of the Grand Banks. The slow eastward progress of this storm had changed by the 23d to a southeastward movement, and on the 25th the center was near Horta. On the following day it was slightly to southward of the western Azores. Then the movement became northwestward, and on the 28th the storm center was near 41° N., 39° W. A more normal northeastward course was then taken, and at the end of the month the storm was slightly south of the fiftieth parallel and close to the thirtieth meridian. There were intense winds in connection with this storm, especially on the 23d, when the Belgian steamship *Emanuel Nobel* met force 12 north of the Azores, and from the 27th to 29th, when the Italian liner *Conte di Savoia* and the American liner *President Johnson* noted force 12 and several other vessels force 11.

Fog.—Fog was of slight importance. In the vicinity of the Grand Banks it was about as prevalent as normal in November, two adjacent 5-degree squares, from 40° to 50° N., 45° to 50° W., noting 7 days each. There was decidedly little fog on other portions of the main steamship lanes and near the American coast.

OCEAN GALES AND STORMS, NOVEMBER 1934

Vessel	Voyage		Position at time of lowest barometer		Gale began November—	Time of lowest barometer November—	Gale ended November—	Lowest barometer	Direction of wind when gale began	Direction and force of wind at time of lowest barometer	Direction of wind when gale ended	Direction and highest force of wind	Shifts of wind near time of lowest barometer
	From—	To—	Latitude	Longitude									
NORTH ATLANTIC OCEAN			° ′	° ′				*Inches*					
Author, Br. S. S.	St. Thomas	Gibraltar	33 17 N.	28 28 W.	[1] 31	8p, 31 [1]	2	29.81	NNE.	NNE, 8	NE.	NE, 11	Steady.
West Ekonk, Am. S. S.	Gibraltar	Galveston	33 30 N.	19 45 W.	1	6p, 1	2	29.26	SW.	S, 6	NE.	NE, 11	SSW-S-E.
Pres. Harrison, Am. S. S.	do	New York	42 58 N.	55 15 W.	3	Mdt, 2	3	29.72	NW.	S, 7	NW.	NW, 10	S-NW.
Nemaha, Am. S. S.	New Orleans	Havre	48 00 N.	24 40 W.	3	2p, 3	4	29.95	NW.	NW, 10	NNE.	NW, 10	NW-NNE.
Pres. Roosevelt, Am S. S.	Cobh	New York	51 00 N.	17 00 W.	4	11p, 3	4	29.73	NE.	W, 4	NE.	NE, 8	W-NE.
Shenandoah, Am. S. S.	Port Arthur	Antwerp	49 30 N.	18 05 W.	8	6p, 8	9	29.36	NW.	NW, 7	N.	NNW, 9	W-NW-NNW.
Duivendrecht, Du. M. S.	New Orleans	Avonmouth	50 36 N.	14 11 W.	9	Mdt, 10	11	29.84	N.	N, 7	N.	N, 9	N-NE.
Imlay, Am. S. S.	Caripeto	New York	37 00 N.	71 46 W.	10	Mdt, 10	11	29.50	NE.	NNE, 9	N.	NE, 9	NE-NNE.
San Diego, Fr. S. S.	Havre	Cristobal	48 32 N.	5 28 W.	12	Noon, 11	14	29.64	NW.	NNW, 7	NW.	NW, 10	NNE-NNW.
Steelmaker, Am. S. S.	Swansea	Montreal	53 10 N.	20 02 W.	12	6a, 12	13	29.36	SW.	W, 7	NNW.	NW, 9	SW-W-WNW.
Braheholm, Swed. S. S.	Newcastle	Baltimore	57 35 N.	19 30 W.	12	11a, 12	14	[2] 29.08	WSW.	WSW, 8	NW.	WSW, 11	3 points.
Yuri Maru, Jap. S. S.	Hamburg	New York	43 38 N.	50 36 W.	13	6p, 13	13	29.50	SSW.	S, 7	WSW.	SSW, 9	2 points.
Sundance, Am. S. S.	Jacksonville	London	33 12 N.	76 51 W.	14	11a, 14	15	29.95	N.	NNW, 7	N.	N, 10	W-NNW-N.
Yuri Maru, Jap. S. S.	Hamburg	New York	41 47 N.	62 40 W.	15	Mdt, 15	16	29.38	NE.	N, 10	NW.	N, 11	2 points.
F. W. Abrams, Am. S. S.	Caripeto	Montreal	42 43 N.	58 34 W.	15	4a, 16	17	29.00	NE.	N, 9	W.	N, 10	NNE-N.
Tercero, Nor. M. S.	Danzig	Albany	40 50 N.	58 00 W.	15	5a, 16	16	28.82	S.	NW, 10	NW.	NW, 10	S-NW.
Burgerdyk, Du. S. S.	Rotterdam	New York	45 22 N.	52 31 W.	16	3p, 16	16	28.38	SSE.	SSE, 6	NW.	NW, 9	SSE-NW.
Steelmaker, Am. S. S.	Swansea	Montreal	53 24 N.	45 30 W.	16	3a, 17	18	28.34	SE.	SW, 8	W.	W, 10	S-W-WNW.
Braheholm, Swed. S. S.	Newcastle	Baltimore	52 00 N.	42 05 W.	16	6a, 17	18	[2] 28.76	S.	W, 9	W.	W, 12	6 points.
Gripsholm, Swed. M. S.	Gothenburg	New York	55 05 N.	34 15 W.	17	Noon, 17	18	28.98	SSE.	S, 10	W.	W, 11	SSE-S-SW.
Gorm, Dan. S. S.	Shields	Norfolk	56 47 N.	26 03 W.	18	10a, 18	21	29.67	WSW.	W, 9	W.	W, 11	
Exeter, Am. S. S.	Almeria, Spain	Boston	42 55 N.	41 12 W.	22	6p, 22	23	29.46	SW.	NW, 10	NW.	NW, 10	{WSW-NW-NNW.
Nemaha, Am. S. S.	Rotterdam	Boca Grande, Fla.	41 10 N.	27 45 W.	23	3p, 23	23	29.62	SSE.	SSE, 10	SSW.	SSE, 10	SSE-SSW.
Emanuel Nobel, Belg. S. S.	Houston	Ghent	41 24 N.	27 39 W.	22	5p, 23	23	29.26	S.	S, 10	WNW.	S, 12	S-WNW.
Sundance, Am. S. S.	Jacksonville	London	47 11 N.	32 36 W.	23	8p, 23	24	28.89	NNE.	E, 9	SSE.	SSE, 11	N-E-SSE.
Fauna, Du. S. S.	Amsterdam	San Juan	[3] 33 45 N.	29 33 W.	23	Mdt., 23	23	29.58	W.	SW, 5	WNW.	NW, 9	NW-SW-W.
Alexandre Andre, Belg. M. S.	Baytown, Tex.	Avonmouth	45 10 N.	34 50 W.	21	3a, 24	22	29.02	NNW.	NE, 5	N.	NNW, 9	N-ENE.
Eglantine, Am. S. S.	New Orleans	London	37 17 N.	70 15 W.	24	4p, 24	27	29.86	NNW.	NNW, 9	ENE.	NNE, 9	NNW-N.
Oldham, Am. M. S.	Gibraltar	New York	38 32 N.	69 50 W.	24	10p, 24	25	29.82	NNW.	NNW, 8	N.	NNW, 8	NNW-N.
Lafcomo, Am. S. S.	Houston	Barcelona	35 23 N.	31 48 W.	26	11p, 24	26	29.44	E.	SW, 3	ESE.	ESE, 8	W-SW-SE.
Carabobo, Am. S. S.	La Guaira	New York	28 00 N.	70 00 W.	25	6a, 25	26	29.70	N.	N, 7	NE.	N, 8	NNW-N.
Fauna, Du. S. S.	Amsterdam	San Juan	30 16 N.	34 23 W.	25	Noon, 25	25	29.49	NW.	NNW, 8	NNW.	NNW, 8	NW-NNW.
Queen of Bermuda, Br. S. S.	New York	Bermuda	33 43 N.	66 01 W.	25	2a, 26	26	29.88	NE.	NE, 8	NE.	NE, 9	Steady.
Frode, Dan. S. S.	Antwerp	Boston	49 04 N.	43 27 W.	26	8p, 26	28	29.75	NNE.	NNE, 9	N.	NNE, 10	SW-NNE.
Meanticut, Am. S. S.	Hamburg	Tampa	24 50 N.	69 43 W.	27	10p, 26	27	29.38	ENE.	S, 5	ENE.	ENE, 8	SW-S-ENE.
Conte di Savoia, Ital, S. S.	New York	Gibraltar	39 37 N.	26 18 W.	26	8a, 27	28	29.45	ESE.	SE, 12	SE.	SE, 12	ESE-SE.
Lustrous, Br. S. S.	Malmo	Port Arthur	29 02 N.	55 14 W.	27	8p, 27	28	30.00	NE.	NE, 8	NE.	NE, 8	None.
Paris, Fr. S. S.	New York	Havre	[3] 47 55 N.	39 35 W.	26	11p, 27	27	29.25	NE.	E, 6	N.	N, 11	NNW-E.
Santarosa, Ital. S. S.	Gibraltar	Pensacola	27 20 N.	54 50 W.	28	11a, 28	28	30.10	ENE.	ENE, 8	ENE.	ENE, 9	None.
Tuscarora, Br. S. S.	Southampton	Aruba	38 27 N.	35 41 W.	26	4p, 28	29	29.10	E.	SW, 9	WSW.	SW, 11	
Pres. Johnson, Am. S. S.	Gibraltar	New York	40 44 N.	41 40 W.	28	4p, 28	30	28.81	NW.	NW, 8	N.	NNW, 12	NW-N.
American Farmer, Am. S. S.	New York	Plymouth	41 30 N.	44 00 W.	27	4p, 28	28	28.96	NNW.	N, 7	WNW.	N, 11	WNW-N.
West Hika, Am. S. S.	Antwerp	Panama City, Fla.	41 20 N.	35 00 W.	28	11p, 28	29	28.50	SSW.	SSW, 8	NW.	SSW, 9	SSW-SW.
Fauna, Du. S. S.	Amsterdam	San Juan	[3] 23 33 N.	50 05 W.	29	4a, 29	29	29.83	NNE.	SE, 4	NE.	NNE, 8	E-SE-NNE.
McKeesport, Am. S. S.	New York	Havre	[3] 48 02 N.	35 11 W.	27	Noon, 29	28	28.92	N.	ESE, 7	NE.	N, 9	ENE-ESE-E.
American Importer, Am. S. S.	do	Liverpool	[3] 41 25 N.	47 10 W.	27	8p, 29	30	29.58	N.	NW, 9	NW.	NW, 11	None.
Black Gull, Am. S. S.	do	Rotterdam	44 01 N.	45 53 W.	27	Mdt., 29.	[4]	29.57	NE.	NNW, 9	NNW.	N, 11	Do.
NORTH PACIFIC OCEAN													
Olympia, Am. S. S.	Legaspi, P. I.	San Francisco	27 30 N.	149 54 E.	1	10a, 31 [1]	2	29.95	E.	NE, 5	E.	E, 8	None.
Empress of Japan, Br. S. S.	Honolulu	Yokohama	[5]	[5]	2	6a, 2	2	29.64	SE.	S, 8	S.	SE, 9	SE-S.
Golden Peak, Am. S. S.	San Francisco	do	34 20 N.	146 30 E.	2	4a, 3	3	29.85	S.	SSE, 7	SSE.	SSE, 9	SSE-SSW.
Silverhazel, Br. M. S.	Sabang, P. I.	Los Angeles	37 55 N.	138 00 W.	3	6a, 4	4	29.50	SW.	SSW, 9	SSW.	SSW, 9	SW-SSW.
San Diego Maru, Jap. M. S.	Port Costa	Hakodate	49 13 N.	167 44 E.	4	6p, 4	4	29.67	SSW.	SSW, 9	SSW.	SSW, 9	SSW-WSW.
San Julian, Am. S. S.	Yokohama	Los Angeles	40 24 N.	133 24 W.	4	2p, 4	4	29.50	SW.	SSW, 9	SW.	SSW, 10	SSW-SW.
Makawao, Am. S. S.	Port Allen, T. H.	San Francisco	27 53 N.	148 39 W.	4	4p, 4	4	29.78	N.	N, 6	N.	N, 8	None.
Pres. McKinley, Am. S. S.	Seattle	Yokohama	48 06 N.	171 30 E.	4	10p, 4	4	30.05	SW.	SSW, 8	SSW.	SSW, 8	SW-SSW-WSW.
California, Ital. S. S.	Vancouver, B. C.	San Francisco	47 06 N.	125 30 W.	4	Mdt., 4	5	29.50	S.	S, 8	SSW.	S, 8	S-SW.
Shoyo Maru, Jap. S. S.	Tokuyama	Los Angeles	38 27 N.	159 50 W.	9	2p, 9	9	[3] 29.47	WNW.	WNW, 10	NW.	WNW, 10	W-WNW-NW.
Olympia, Am. S. S.	Legaspi, P. I.	San Francisco	37 57 N.	172 10 E.	7	4p, 9	10	29.88	E.	SE, 10	S.	SE, 10	SE-S.
Atlantic City, Br. S. S.	Dairen, Manchuria	Los Angeles	40 38 N.	138 00 W.	9	3p, 9	11	29.50	SSW.	SSW, 10	SSW.	SSW, 10	None.
Varanger, Nor. M. S.	Shanghai	do	41 30 N.	139 00 W.	10	11a, 10	11	29.21	SW.	SSW, 4	SW.	SW, 9	ESE-SSW.
Aorangi, Br. M. S.	Victoria, B. C.	Honolulu	38 35 N.	141 00 W.	10	do	11	29.35	S.	SW, 8	W.	WSW, 10	SSE-SW-W.
Peter Kerr, Am. S. S.	Yokohama	Los Angeles	41 40 N.	142 00 W.	10	8p, 10	11	28.76	SE.	SSW, 10	W.	SSW, 10	SW-SSW-W.
Golden Dragon, Am. S. S.	Otaru, Japan	San Francisco	44 16 N.	140 00 W.	10	1a, 11	11	28.77	E.	SW, 9	SSW.	SW, 10	SE-SW-SSW.
Athelchief, Br. M. S.	Nagoya	San Pedro	39 31 N.	147 31 W.	10	Noon, 10	11	[2] 29.06	SW.	WNW, 11	W.	WNW, 12	SW-WNW-W.
Jeff Davis, Am. M. S.	Balboa	Los Angeles	14 15 N.	95 30 W.	12	4p, 12	12	29.87	N.	NNE, 8	NW.	NNW, 8	NNW-NNE.
Pres. Jefferson, Am. S. S.	Yokohama	Victoria, B. C.	49 48 N.	137 42 W.	13	4a, 14	14	29.13	NNE.	NE, 8	NE.	NNE, 9	NNE-E.
Empress of Russia, Br. S. S.	do	Vancouver, B. C.	48 50 N.	178 56 E.	14	do	14	29.14	WNW.	W, 7	W.	WNW, 9	W.
Dryden, Am. S. S.	Los Angeles	Yokohama	32 56 N.	156 48 E.	15	3a, 15	15	29.53	SSW.	SSW, 9	SSW.	SSW, 9	S-SSW-NW.
Teiyo Maru, Jap. M. S.	do	do	33 12 N.	164 05 E.	15	2p, 15	15	29.59	SSW.	W, 6	SW.	SSW, 8	SSW-W.
Arthur J. Baldwin, Am. S. S.	Nome	Seattle	54 23 N.	155 30 W.	16	2p, 16	16	29.01	SE.	ESE, 8	SSE.	E, 9	SE-SSE.
Seattle, Am. S. S.	Philippine Is.	Los Angeles	41 24 N.	174 51 W.	20	Noon, 20	20	29.58	S.	SSW, 9	SW.	SSW, 9	S-SW.
Nitro, U. S. N.	Balboa	San Diego	15 19 N.	93 49 W.	22	4p, 22	22	29.74	NW.	WNW, 3	N.	NNW, 8	WNW-NW.
Pres. Jackson, Am. S. S.	Yokohama	Victoria, B. C.	50 00 N.	167 33 W.	22	do	24	28.50	ENE.	NE, 8	W.	WNW, 10	ENE-NE-SE.
China Arrow, Am. S. S.	Los Angeles	Balboa	14 55 N.	95 30 W.	23	Noon, 23	24	29.79	NE.	NE, 6	N.	NE, 9	NNE-NE.
Pres. Jefferson, Am. S. S.	Victoria, B. C.	Yokohama	51 55 N.	136 50 W.	26	10a, 26	26	29.49	WSW.	W, 7	W.	WSW, 8	ESE-W.
Empress of Japan, Br. S. S.	Yokohama	Honolulu	24 50 N.	165 14 W.	27	Noon, 28	28	29.96	N.	N, 8	N.	NE, 9	Steady.
San Diego Maru, Jap. M. S.	Nigata, Japan	Los Angeles	42 23 N.	155 22 E.	27	do	30	28.89	S.	SW, 4	SSW.	WSW, 10	SW-W.
City of Elwood, Am. M. S.	Hong Kong	do	30 06 N.	162 38 W.	29	2p, 30	30	29.87	NNE.	ENE, 5	NNE.	NNE, 8	NE-ENE.

[1] October. [2] Barometer uncorrected. [3] Position approximate. [4] Dec. 1. [5] Gulf of Tokyo.

NORTH PACIFIC OCEAN, NOVEMBER 1934

By WILLIS E. HURD

Atmospheric pressure.—The dominant average pressure conditions over the North Pacific Ocean during November 1934 consisted, as in the previous month, of a deep Aleutian cyclone covering much of higher latitudes, but central in the neighborhood of the Gulf and Peninsula of Alaska (Kodiak 29.42 inches); and the usual middle-latitude anticyclone, central west of California, but extending in a wide belt westward to the continental anticyclone in middle Asiatic waters.

Along the coast region from the central Aleutians eastward to Juneau and thence southward to the State of Washington, pressures were abnormally low, as they were also in midocean from the Aleutians southward to Midway Island. Near normal pressures prevailed between the Hawaiian Islands and the American mainland from California southward.

TABLE 1.—*Averages, departures, and extremes of atmospheric pressure at sea level, North Pacific Ocean, November 1934 at selected stations*

Stations	Average pressure	Departure from normal	Highest	Date	Lowest	Date
	Inches	*Inch*	*Inches*		*Inches*	
Point Barrow	30.01	+0.02	30.46	14	29.30	5
Dutch Harbor	29.51	−.08	30.14	11	28.74	16
St. Paul	29.53	−.06	30.26	10, 11	28.82	17
Kodiak	29.42	−.14	29.72	20	29.00	1
Juneau	29.63	−.13	29.99	11	29.12	1
Tatoosh Island	29.85	−.12	30.29	29	29.26	2
San Francisco	30.10	+.01	30.34	28	29.72	18
Mazatlan	29.91	+.02	29.96	11, 19	29.84	3, 8, 20
Honolulu	30.02	.00	30.14	16	29.82	28
Midway Island	30.00	−.08	30.34	28	29.76	3, 4
Guam	29.88	+.02	30.00	15	29.72	10, 30
Manila	29.81	−.02	29.92	8, 11	29.50	14, 29
Hong Kong	30.02	------	30.14	21	29.87	17
Naha	30.07	+.09	30.22	28	29.82	6
Chichishima	30.05	+.07	30.22	29	29.82	7
Nemuro	29.84	------	30.40	4, 24	29.30	27

NOTE.—Data based on 1 daily observation only, except those for Juneau, Tatoosh Island, San Francisco, and Honolulu, which are based on 2 observations. Departures are computed from best available normals related to time of observation.

Cyclones and gales.—Cyclonic activity was almost uninterrupted throughout the Aleutian region during November. This was especially true of southern Alaskan waters where, at Kodiak, the highest pressure of the month was only 29.72 inches.

Heavy storminess for this region, however, as also for practically all parts of the ocean, appears to have been less widespread and intense than during the preceding October.

During the early part of the month—from the 1st to 5th—scattered gales of force 8–9 occurred along much of the length of the upper steamship routes. In the Far East they were the result of a moderate cyclone in Japanese waters. In the higher American coast region they were due to a deep and extensive disturbance of the Aleutian type, the influence of which extended as far southward as the Oregon coast. Gales on the 4th near 40° N., 130°–140° W., rose in intensity to force 10.

On November 8 a cyclone secondary to the principal Aleutian storm gathered in a trough of low pressure that extended as far equatorward as the latitude of the Hawaiian Islands. By the 9th it had developed the force of a strong gale (9), and by the 10th, central near 42°–43° N., 142° W., it had deepened to about 28.75 inches, and was causing southwesterly gales of force 10 over the area embraced approximately between 38°–45° N., 135°–150° W. About noon of the 10th the British motorship *Athelchief*, in 39°31′ N., 147°31′ W., according to a special report, was experiencing a gale of force 11, WNW., and at 4 p. m. had entered a belt of wind, also WNW., of hurricane velocity. This is the maximum wind force thus far reported on the North Pacific for the month. The storm abated in intensity as it moved northward on the 11th, and by the 12th had entered the low-pressure region of the month in south-Alaskan waters.

Following this storm, which may be considered the major extratropical disturbance of the month, widely scattered gales, mostly of fresh to strong force, occurred in several localities on the 14th to 16th.

On the 22d–24th, during an intensification of the Aleutian cyclone in middle longitudes, the American S. S. *President Jackson* reported easterly changing to westerly gales, highest force 10, on the 23d; lowest pressure 28.50, on the 22d, in 50° N., 167½° W. Fresh westerly gales accompanied this disturbance until the 26th, reaching as far eastward on this date as 137° W., in 52° north latitude.

On the 27th and 28th a storm, central over northern Japan and the Kuril Islands, caused gales in the vicinity. Stormy conditions continued to the eastward on the 29th, with the Japanese motorship *San Diego Maru* reporting a force of 10, SSW., with a low barometer of 28.89 inches, near 42° N., 155° E.

During the 28th to 30th a depression formed over the Hawaiian Islands. On all 3 days northeasterly gales of force 8 to 9 occurred as a result within the area 24°–31° N., 160°–170° W.

Typhoons.—Two typhoons of some intensity crossed the Philippine Islands in November. One appears to have originated near Yap on the 12th, and to have entered the China Sea on the 15th, after a passage of the islands near Manila on the previous day. The other originated on or about the 25th, east of the Marianas, crossed the Philippines on the 29th, and entered the China Sea on the 30th.

An account of these storms, written by the Rev. Fr. Bernard F. Doucette, S. J., of the Weather Bureau at Manila, will appear in the December issue of the REVIEW.

Tehuantepecers.—In the Gulf of Tehuantepec, Mexico, gales of norther type were reported on the 12th, 17th, 18th, and 22d to 24th. The heaviest gale was that of the 23d–24th, of force 9, from the northeast.

Fog.—Fog was observed on 2 days off the coast of Lower California; on 10 days off California; and on 3 days off the Oregon and Washington coasts. Scattered fog occurred on a few days elsewhere along the northern and middle steamship routes, with the area of greatest frequency, where it was encountered on the 7th to 11th, about midway between the western Aleutians and Japan.

SEA-SURFACE TEMPERATURE SUMMARY FOR THE YUCATAN CHANNEL, 1912–33

By GILES SLOCUM

The monthly mean sea-surface temperatures in the Yucatan Channel for the period, January 1912, to December 1933, inclusive, are given in the accompanying table. There are 6 months, as noted in the table, for which no observational data are available. The observations of sea-surface temperature for the years, 1913 to 1919, inclusive, were few in number, and the average temperatures for this period are therefore given to whole degrees. The mean temperatures for the balance of the 22-year period are given to tenths of a degree.

The area from which these temperature observations were taken embraces five 1° squares, namely: Between 21° N. and 22° N., the two 1° squares between 85° W. and 87° W.; between 22° N. and 23° N., the three 1° squares between 84° W. and 87° W.

TABLE 1.—*Monthly and annual mean sea-surface temperatures in the Yucatan Channel, 1912 to 1933 inclusive*

Year [1]	Total number of observations for the year	January	February	March	April	May	June	July	August	September	October	November	December	Annual [2]
1912	137	78.9	75.9	77.9	79.8	81.2	83.3	83.2	83.2	83.0	81.6	77.2	79.3	80.4
1913	77	78	[3]	78	78	77	81	82	82	83	82	79	78	[4]79.5
1914	51	76	78	77	78	81	82	84	84	84	[3]	79	79	[4]80.4
1915	52	79	78	78	77	81	82	85	83	87	82	82	80	81.0
1916	43	77	77	77	79	80	84	83	83	81	83	80	78	80.2
1917	47	77	76	78	79	80	80	83	85	[3]	82	[3]	76	[4]79.9
1918	25	76	78	79	[3]	78	83	81	82	85	84	77	[3]	[4]79.9
1919	48	77	77	78	78	82	84	83	84	83	83	82	78	80.7
1920	236	77.3	76.8	77.5	78.8	80.8	81.4	82.2	82.4	82.2	81.5	79.6	79.7	80.0
1921	242	75.8	75.8	77.6	78.4	78.3	80.8	81.2	82.2	82.1	80.9	80.1	78.5	79.3
1922	219	77.5	76.9	78.1	78.8	79.5	80.9	81.3	81.9	82.1	82.3	80.4	79.1	79.9
1923	240	77.5	77.8	78.3	79.1	80.1	80.8	82.4	83.5	82.7	81.8	79.1	77.8	80.1
1924	243	77.3	75.2	76.5	78.4	80.7	83.2	83.6	84.2	83.9	81.7	79.7	78.5	80.2
1925	360	78.6	77.2	78.4	78.0	80.2	81.7	82.4	83.2	83.1	82.5	80.6	79.1	80.4
1926	415	77.7	78.0	76.6	79.2	80.7	81.5	83.0	83.5	83.2	83.1	80.5	79.5	80.5
1927	535	77.7	77.3	78.1	79.4	80.7	82.6	82.9	83.6	83.8	82.6	81.0	78.4	80.7
1928	607	76.8	77.8	77.5	78.5	79.5	82.1	82.8	83.7	83.0	83.0	80.9	78.9	80.4
1929	599	77.4	78.7	78.7	79.7	80.0	81.3	82.3	83.0	82.7	81.7	80.3	78.8	80.4
1930	640	78.3	77.5	77.4	78.3	80.7	81.7	82.9	84.3	84.1	82.6	80.6	78.7	80.6
1931	599	78.7	77.3	77.5	77.6	81.0	82.8	83.4	84.1	84.1	82.5	80.5	80.0	80.8
1932	516	79.2	79.3	78.5	78.5	80.4	82.3	83.5	84.4	84.5	83.5	80.8	78.6	81.1
1933	409	78.2	78.7	78.2	80.1	80.5	81.7	83.1	83.5	83.3	82.3	80.6	78.5	80.7
Number of years' record		22	21	22	21	22	22	22	22	21	21	21	21	22
Mean (1912–33) [2]		77.6	77.3	77.8	78.6	80.1	82.0	82.7	83.3	83.4	82.3	80.0	78.7	[4]80.3

[1] Values for 1913 to 1919 inclusive are given to whole degrees, instead of to tenths because of paucity of data.
[2] Computed with monthly values figured to 1 decimal place, and, therefore, not exact means of the figures given here.
[3] No data.
[4] Interpolated values are used for missing months.

CLIMATOLOGICAL TABLES

CONDENSED CLIMATOLOGICAL SUMMARY

In the following table are given for the various sections of the climatological service of the Weather Bureau the monthly average temperature and total rainfall; the stations reporting the highest and lowest temperatures, with dates of occurrence; the stations reporting the greatest and least total precipitation; and other data as indicated by the several headings.

The mean temperature for each section, the highest and lowest temperatures, the average precipitation, and the greatest and least monthly amounts are found by using all trustworthy records available.

The mean departures from normal temperatures and precipitation are based only on records from stations that have 10 or more years of observations. Of course, the number of such records is smaller than the total number of stations.

Condensed climatological summary of temperature and precipitation by sections, November 1934

[For description of tables and charts, see Review, January, p. 37]

Section	Temperature								Precipitation					
			Monthly extremes								Greatest monthly		Least monthly	
	Section average	Departure from the normal	Station	Highest	Date	Station	Lowest	Date	Section average	Departure from the normal	Station	Amount	Station	Amount
	°F.	°F.		°F.			°F.		In.	In.		In.		In.
Alabama	57.6	+3.3	Robertsdale	87	1	St. Bernard	23	13	3.87	+0.58	Millry	16.98	Primrose Farm	1.30
Arizona	52.6	−.2	Gila Bend	98	6	2 stations	0	[1] 27	.86	−.01	Bright Angel Ranger Station.	3.48	Gila Bend	T
Arkansas	54.0	+2.4	4 stations	88	[1] 7	3 stations	20	[1] 12	6.89	+3.19	Arkansas City	12.87	Mountain Home	3.62
California	52.4	.0	Brawley	98	3	Ellery Lake	0.	24	3.90	+1.40	Upper Mattole	15.53	3 stations	.00
Colorado	38.0	+2.8	Palisade	90	1	Pearl	−17	29	.83	+.03	Shoshone	3.30	Deaton's Ranch	.00
Florida	66.7	+1.6	2 stations	91	[1] 4	5 stations	26	13	1.52	−.69	Vernon	9.45	Everglades	T
Georgia	57.4	+2.7	do	89	[1] 1	2 stations	19	[1] 12	1.77	−.90	Clayton	6.58	Augusta	.53
Idaho	40.1	+4.3	Indian Cove	75	10	Prairie	−2	28	2.46	+.40	Roland	7.38	Challis	.14
Illinois	47.0	+5.5	Harrisburg	82	7	Danville	16	15	5.71	+2.98	New Burnside	9.62	Waverly	3.18
Indiana	46.6	+4.2	Butlerville	80	[1] 21	Marengo	12	15	2.87	−.18	Fowler	5.98	Vevay (near)	1.06
Iowa	41.9	+5.6	Little Sioux	79	6	Baxter	11	23	5.03	+3.42	Belle Plaine	9.10	Sheldon	.76
Kansas	47.3	+4.0	Medicine Lodge	87	7	2 stations	13	[1] 28	2.58	+1.29	Winfield	3.15	Richfield	T
Kentucky	50.5	+4.0	Murray	84	1	Farmers	14	14	2.85	−.61	Paducah	9.01	Carrollton	.90
Louisiana	61.9	+2.8	Donaldsonville	92	1	Tallulah	25	15	8.00	+4.12	Monroe	11.95	Jonesville	4.41
Maryland-Delaware	48.0	+2.9	La Plata, Md	80	4	Sines, Md	10	15	3.57	+1.02	Emmitsburg, Md	4.94	Boyds, Md	2.11
Michigan	40.7	+4.3	Hart	74	4	Fenville	13	14	3.88	+1.40	Benzonia	8.65	Port Huron	1.26
Minnesota	35.2	+5.4	Montevideo	79	6	2 stations	4	23	1.43	+.26	Zumbrota	5.07	Fosston	.20
Mississippi	58.1	+2.9	2 stations	87	[1] 2	3 stations	24	[1] 12	7.74	+4.11	Fruitland Park	13.99	Fulton	4.43
Missouri	48.5	+4.0	Garber	84	7	Kidder	16	23	5.68	+3.12	Sikeston	10.04	St. Louis University	2.51
Montana	38.1	+5.8	Grass Range	80	12	3 stations	−1	30	.55	−.44	Heron	5.86	2 stations	.00
Nebraska	41.7	+4.5	2 stations	85	6	Gordon	3	28	1.22	+.44	Auburn	5.37	Springview	T
Nevada	44.2	+4.3	Clay City	93	4	Canyon Creek Ranch.	−6	27	1.06	+.41	Lewers Ranch	3.27	2 stations	T
New England	41.2	+3.2	Waterbury, Conn	77	20	Presque Isle, Maine	3	14	3.29	−.14	Pinkham Notch, N. H.	5.44	Newport, Vt	1.60
New Jersey	47.3	+3.7	Indian Mills	80	20	Runyon	10	15	2.91	−.27	Charlotteburg	5.00	Runyon	1.30
New Mexico	43.3	+.7	Nara Visa	93	8	Elizabethtown	−27	30	.81	+.16	Grady (near)	2.24	Graham ranch	.04
New York	42.0	+4.0	Port Jervis	78	20	Franklinville	2	15	2.77	−.24	Mohonk Lake	5.72	Gabriels	1.33
North Carolina	52.2	+2.3	2 stations	84	8	Mount Mitchell	4	[1] 12	4.98	+2.37	Mount Mitchell	13.10	Manteo	1.08
North Dakota	33.9	+6.5	do	73	[1] 9	Park River	−1	23	.28	−.33	Fullerton	1.04	Dunn Center	.00
Ohio	45.6	+4.1	Portsmouth	81	21	McArthur	13	15	1.92	−.83	Phalanx	3.81	Bellpoint	.74
Oklahoma	53.4	+3.4	Hollis	90	7	Boise City	5	29	3.63	+1.59	Durant	9.23	Hammon	.10
Oregon	43.7	+3.1	2 stations	79	5	Seneco	0	30	5.66	+1.87	Haskins Dam	22.51	Mitchell	.61
Pennsylvania	44.9	+3.7	Clairton	80	22	2 stations	6	15	3.61	+.75	Mauch Chunk	7.38	Smethport	1.03
South Carolina	55.2	+1.5	3 stations	85	[1] 4	Santuck	18	15	2.73	+.41	Caesars Head	7.82	Trenton	T
South Dakota	39.1	+6.1	Murdo	80	16	Ardmore	6	28	.47	−.20	Harveys Ranch	1.15	Pollock	.00
Tennessee	52.3	+3.6	3 stations	84	[1] 8	Rugby	15	15	4.10	+.52	Memphis	13.21	Rock Island	1.37
Texas	60.9	+3.7	2 stations	98	[1] 1	Dalhart	16	[1] 29	3.95	+1.63	Matagorda	13.53	2 stations	.00
Utah	40.3	+2.7	do	85	6	2 stations	−4	[1] 27	1.75	+.79	Silverlake	6.27	Hanksville	.10
Virginia	49.0	+2.4	Stuart	85	5	Burkes Garden	11	15	4.46	+2.08	Roanoke	9.22	Holland	1.68
Washington	43.7	+2.9	Lowden	80	5	Republic	10	30	7.25	+1.96	Mount Baker Lodge	31.82	Sunnyside	.93
West Virginia	46.6	+3.4	3 stations	80	[1] 21	Pickens	8	15	3.30	+.53	Charleston	5.45	Dam No. 26 O. R.	1.79
Wisconsin	38.3	+4.9	Brodhead	69	20	Big St. Germain Dam.	−2	14	5.15	+3.28	Williams Bay	8.95	Spooner	1.34
Wyoming	35.5	+3.7	2 stations	78	[1] 6	Wamsutter	−14	30	.64	−.07	Bechler River	4.72	Basin	T
Alaska (October)	34.6	+3.3	Matanuska	69	31	Allakaket	−12	24	3.77	−.10	Cordova	28.20	Barrow	.02
Hawaii	73.4	+1.4	2 stations	92	[1] 2	Kanalohuluhulu	44	[1] 1	8.19	−.38	Puohakamoa No. 2	41.00	Olowalu	.00
Puerto Rico	76.9	−.4	San German	95	20	Cayey	54	27	4.98	−2.44	Rio Blanco	12.25	Coamo	.55

[1] Other dates also.

TABLE 1.—*Climatological data for Weather Bureau stations, November 1934*

[Compiled by Annie E. Small]

District and station	Elevation of instruments: Barometer above sea level	Elevation of instruments: Thermometer above ground	Elevation of instruments: Anemometer above ground	Pressure: Station, reduced to mean of 24 hours	Pressure: Sea level, reduced to mean of 24 hours	Pressure: Departure from normal	Temperature of the air: Mean max.+ mean min.÷2	Temperature of the air: Departure from normal	Temperature of the air: Maximum	Temperature of the air: Date	Temperature of the air: Mean maximum	Temperature of the air: Minimum	Temperature of the air: Date	Temperature of the air: Mean minimum	Temperature of the air: Greatest daily range	Mean wet thermometer	Mean temperature of the dew point	Mean relative humidity	Precipitation: Total	Precipitation: Departure from normal	Precipitation: Days with .05 or more	Wind: Total movement	Wind: Prevailing direction	Wind: Maximum velocity: Miles per hour	Wind: Maximum velocity: Direction	Wind: Maximum velocity: Date	Clear days	Partly cloudy days	Cloudy days	Average cloudiness, tenths	Total snowfall	Snow, sleet, and ice on ground at end of month
	Ft.	*Ft.*	*Ft.*	*In.*	*In.*	*In.*	°F.	°F.	°F.		°F.	°F.		°F.	°F.	°F.	°F.	%	*In.*	*In.*		*Miles*								*0–10*	*In.*	*In.*
New England							43.5	+4.0										79	2.84	−0.4										7.0		
Eastport	76	67	85	30.02	30.11	+0.10	40.2	+3.5	59	5	46	21	15	34	22	38	35	81	3.52	+0.2	12	8,327	sw.	47	e.	11	5	4	21	7.6	2.7	0.0
Greenville, Me	1,070	6	40	29.91	30.09		34.6		58	23	41	12	26	29	24				2.42		13	4,612	nw.	20		1	3	1	26		5.8	
Portland, Me	103	82	117	30.00	30.12	+.11	41.5	+3.5	66	5	48	21	26	35	28	38	34	78	3.11	−.4	15	6,144	n.	35	s.	4	11	5	14	5.8	1.8	.0
Concord	289	60					41.2	+3.5	66	5	49	16	15	33	35				2.96	−.1	11		ne.				3	14	13		1.0	.0
Burlington	403	11	48	29.64	30.09	+.04	39.1	+2.8	62	23	45	17	26	33	22				2.47	−.2	16	8,784	s.	38	s.	22	0	6	24	9.1	.5	.0
Northfield	876	12	60	29.15	30.12	+.07	37.6	+4.8	61	23	45	9	15	30	34	35	33	85	2.63	−.3	17	5,854	s.	28	s.	4	0	6	24	8.8	1.6	.0
Boston	124	336	360	29.98	30.12	+.07	45.6	+3.6	69	5	53	23	15	38	26	42	38	76	1.78	−1.6	11	10,291	w.	38	w.	1	6	10	14	6.5	T	.0
Nantucket	12	14	90	30.11	30.12	+.07	47.7	+3.3	63	20	53	33	13	42	20	44	41	80	2.54	−.7	10	11,006	s.	40	sw.	1	6	7	17	6.9	T	.0
Block Island	26	11	46	30.08	30.11	+.05	47.8	+3.2	65	20	53	27	15	43	23	45	42	82	2.27	−1.4	12	12,663	w.	44	nw.	6	8	7	15	6.3	.0	.0
Providence	160	215	251	29.95	30.13	+.06	45.6	+5.2	68	20	53	22	15	38	25	41	37	74	3.88	+.8	12	8,110	nw.	38	nw.	1	10	10	10	5.4	T	.0
Hartford	159	70	104		30.13	+.05	45.5	+6.0	60	20	53	22	15	38	26				2.79	−.8	13	5,842	s.				8	7	15		T	.0
New Haven	106	74	153	30.02	30.14	+.07	46.7	+4.7	70	20	54	24	15	40	24	42	38	74	3.28	−.1	11	6,655	nw.	31	s.	4	7	8	15	6.5	T	.0
Middle Atlantic States							48.8	+3.9										73	2.97	+0.4										6.3		
Albany	97	107	115	30.02	30.12	+.04	43.9	+4.6	65	23	50	20	15	38	23	41	37	80	2.26	−.5	14	5,625	s.	25	s.	23	1	3	26	8.4	T	.0
Binghamton	871	60	68	29.16	30.11	+.02	44.2	+5.5	74	20	51	17	15	38	29				2.19	−.2	12	4,750	w.	18	s.	23	2	4	24	8.5	.5	.0
New York	314	415	454	29.78	30.13	+.04	48.2	+4.0	74	20	55	25	14	42	26	43	38	70	1.69	−1.3	12	11,323	nw.	61	nw.	1	9	7	14	6.0	T	.0
Bellefonte	1,050	5	42	28.99	30.12		43.3		68	18	52	17	15	35	32	39	36	80	2.89		12		sw.				3	6	21	7.8	T	.0
Harrisburg	374	94	104	29.73	30.13	+.02	47.3	+4.5	70	4	54	27	15	40	27	42	36	69	3.82	+1.6	12	5,673	w.	29	w.	7	10	6	14	6.2	T	.0
Philadelphia	114	123	367	30.02	30.15	+.05	50.6	+4.9	75	20	58	28	15	44	23	45	39	69	2.64	−.1	11	9,680	nw.	44	s.	4	10	6	14	5.8	T	.0
Reading	328	283	306	29.78	30.14		48.6	+6.1	76	20	56	26	15	41	26	43	37	70	2.85	+.1	11	9,772	nw.	41	s.	4	9	7	14	6.2	T	.0
Scranton	805	72	104	29.25	30.13	+.04	45.6	+5.1	75	20	52	21	15	39	27	41	37	78	3.09	+.3	11	5,412	sw.	23	se.	22	4	11	15	7.0	T	.0
Atlantic City	52	37	172	30.08	30.14	+.04	49.6	+4.0	68	5	56	25	15	43	24	45	40	74	2.83	.0	11	12,541	w.	52	s.	4	9	7	14	5.9	T	.0
Sandy Hook	22	10	57	30.10	30.12		48.4		69	20	54	28	15	43	20	44	40	75	1.77	−1.5	12	11,105	nw.	38	s.	4	9	8	13	6.1	T	.0
Trenton	190	88	106	29.93	30.13		48.1	+3.7	75	20	56	25	15	40	29	43	38	74	1.97	−.8	12	7,435	nw.	33	nw.	1	9	9	12	5.8	T	.0
Baltimore	123	100	215	30.00	30.13	+.02	50.5	+4.2	78	4	58	27	15	43	28	44	38	69	3.51	+1.0	12	7,688	sw.	34	se.	4	11	7	12	5.5	T	.0
Washington	112	62	85	30.02	30.14	+.02	49.6	+4.4	78	4	59	27	15	40	28	43	38	71	3.58	+1.2	11	5,394	nw.	31	nw.	1	10	7	13	5.8	T	.0
Cape Henry	18	8	54	30.12	30.14		53.2	+1.1	76	1	61	29	13	46	31	48	43	73	1.97	−.4	10	9,965	se.	38	n.	9	9	12	9	5.2	.0	.0
Lynchburg	686	5		29.40	30.16	+.03	49.6	+2.4	79	19	63	20	15	37	49				6.11	+3.8	12		n.				9	14	7		.0	.0
Norfolk	91	170	205	30.06	30.16	+.05	54.7	+3.3	76	22	63	27	13	46	28	48	43	72	2.35	+.2	11	9,624	s.	38	nw.	5	10	9	11	5.6	.0	.0
Richmond	144	11	52	30.01	30.16	+.04	51.1	+2.8	80	4	62	26	15	40	42	44	39	73	3.34	+1.1	9	6,237	ne.	27	sw.	13	10	9	11	5.1	T	.0
Wytheville	2,304	49	55		30.15	+.02	45.4	+2.4	70	19	55	22	25	36	39			72	4.49	+2.4	15	6,023	w.	30	w.	13	14	4	12		1.0	.0
South Atlantic States							56.9	+2.7										74	3.21	+0.8										4.3		
Asheville	2,253	89	104	27.79	30.18	+.04	48.6	+3.5	74	18	60	23	15	37	45	41	37	72	4.53	+2.3	11	7,186	nw.	32	se.	22	15	5	10	4.6	T	.0
Charlotte	779	63	86	29.31	30.16	+.03	53.6	+3.0	78	8	63	30	15	44	32	46	41	69	3.08	+.5	8	5,563	ne.	22	n.	14	16	5	9	4.2	.0	.0
Greensboro	886	6	56	29.19	30.17		49.4		78	4	62	20	15	37	*44	43	39	80	3.30		9	6,451	sw.	28	w.	5	14	4	12	4.9	T	.0
Hatteras	11	5	50	30.12	30.13	+.02	58.9	+2.6	75	21	65	39	13	52	23	54	51	78	1.19	−2.3	10	10,863	n.	37	n.	14	13	9	8	4.7	.0	.0
Raleigh	376	103	146	29.74	30.15	+.02	53.8	+2.8	80	8	64	26	15	44	30	47	42	70	8.04	+5.8	11	7,085	sw.	27	ne.	14	12	8	10	4.8	T	.0
Wilmington	72	73	107	30.08	30.16	+.04	57.6	+1.6	79	4	67	29	15	48	33	51	47	77	7.70	+5.7	8	6,832	n.	32	s.	4	16	7	7	3.7	T	.0
Charleston	48	11	92	30.10	30.15	+.03	59.7	+1.6	81	4	68	35	15	52	30	54	50	76	2.64	+.5	5	7,889	n.	30	n.	14	17	3	10	4.1	.0	.0
Columbia, S. C	351	41	57	29.77	30.16	+.04	56.7	+2.7	81	8	67	29	13	46	37	49	44	72	3.18	+1.2	8	5,485	ne.	20	sw.	1	18	5	7	3.8	.0	.0
Greenville, S. C	1,039	139					53.4	+3.8	78	7	64	27	13	43	32				2.96	−.2	5		sw.				18	1	11			.0
Augusta	182	62	77	29.94	30.14	+.01	57.6	+3.1	81	8	69	29	13	46	42	50	45	71	.53	−1.9	8	4,542	nw.	21	sw.	1	17	3	10	3.9	.0	.0
Savannah	65	73	152	30.07	30.14	+.02	61.6	+3.1	83	4	72	34	15	51	35	53	49	75	1.12	−1.0	6	7,658	n.	26	s.	4	16	6	8	3.9	.0	.0
Jacksonville	43	86	110	30.08	30.13	+.03	64.3	+2.1	84	3	73	35	13	56	30	57	54	79	.31	−1.7	5	6,044	ne.	21	ne.	27	12	10	8	4.4	.0	.0
Florida Peninsula							72.1	+1.1										74	1.55	−0.7										4.3		
Key West	22	10	64	30.01	30.03	+.01	74.7	+.4	85	5	79	62	13	70	11	68	65	77	2.12	−.1	7	7,258	ne.	21	W.	1	15	8	7	4.1	.0	.0
Miami	25	124	168	30.04	30.07	+.01	72.6	+.8	84	2	78	48	13	67	25	65	61	70	2.26	−.6	12	7,735	ne.	22	ne.	15	8	11	11	5.5	.0	.0
Tampa	35	88	197	30.06	30.10	+.02	69.0	+2.1	85	28	78	42	13	59	29	60	57	76	.28	−1.4	1	8,338	ne.	25	e.	19	16	13	1	3.3	.0	.0
Titusville	43	5	36	30.04	30.10		67.7		89	4	79	38	13	56	35				.32		2		nw.				10	17	3		.0	.0
East Gulf States							59.1	+3.0										72	3.83	+0.6										3.9		
Atlanta	1,173	128	135	28.90	30.15	+.02	54.0	+1.9	78	8	63	30	12	45	27	47	42	71	1.66	−1.4	10	7,637	nw.	26	se.	22	16	4	10	4.0	.0	.0
Macon	370	79	87	29.75	30.15	+.02	57.2	+3.0	81	8	69	27	16	45	40	49	42	68	1.19	−1.3	8	5,445	nw.	24	s.	22	19	1	10	3.6	.0	.0
Thomasville	273	49	58	29.84	30.15	+.03	61.4	+2.9	84	1	72	31	13	50	35	54	49	73	1.67	−1.0	5		ne.				13	7	10		.0	.0
Apalachicola	35	11		30.08	30.12		62.7		82	1	70	39	13	56	26	57			5.57	+2.5	6		n.				16	6	8		.0	.0
Pensacola	56	149	185	30.05	30.11	.00	63.2	+3.0	82	1	71	40	12	55	26	56	52	72	2.35	−1.4	7	10,207	e.	47	s.	21	20	4	6	3.4	.0	.0
Anniston	741	9					54.7	+2.8	79	8	66	26	13	43	40				3.21	.0	10		se.				17	3	10		.0	.0
Birmingham	700	11	48	29.35	30.13	+.01	56.2	+2.3	80	10	66	30	12	46	33	48	43	69	3.14	−.2	8	5,724	se.	34	se.	21	17	5	8	3.8	.0	.0
Mobile	57	125	161	30.04	30.10	−.01	62.0	+3.4	82	9	71	39	12	53	26	56	52	76	5.31	+1.7	6	7,566	n.	38	se.	21	17	6	7	3.9	.0	.0
Montgomery	218	92	105	29.89	30.14	+.02	58.4	+2.6	80	8	68	33	13	48	37	51	46	70	2.25	−1.0	7	5,345	e.	24	se.	21	17	4	9	3.9	.0	.0
Meridian	375	67	92	29.71	30.12	.00	58.2	+4.0	82	9	69	30	13	47	37	51	47	79	6.44	+3.1	7	4,787	se.	26	se.	21	16	4	10	4.2	.0	.0
Vicksburg	247	65	73	29.83	30.09	−.03	59.8	+3.2	82	10	69	38	23	50	27	52	47	70	7.42	+3.7	9	5,566	se.	29	se.	29	15	5	10	4.5	.0	.0
New Orleans	53	76	84	30.04	30.09	−.01	65.4	+3.8	84	1	73	45	24	58	20	58	54	74	5.75	+2.6	9	5,130	ne.	21	sw.	29	15	6	9	4.3	.0	.0
West Gulf States							62.1	+4.4										72	5.15	+2.3										4.3		
Shreveport	249	92	227	29.80	30.08	−.03	60.1	+4.1	84	8	70	37	23	51	31	52	46	68	9.12	+5.5	11	8,331	se.	34	w.	20	15	6	9	4.4	.0	.0
Bentonville	1,303	11	44	28.64	30.02	−.09	51.6	+4.9	80	7	62	26	23	41	34				6.42		8	4,929	s.	21	sw.	21	12	2	16		9.2	6.0
Fort Smith	457	79	94	29.56	30.05	−.06	53.8	+2.8	78	7	63	31	23	45	34	46	40	67	6.75	+3.9	10	6,335	e.	28	sw.	3	13	5	12	5.1	T	.0
Little Rock	357	94	102	29.69	30.08	−.04	54.4	+2.3	81	7	64	34	23	45	34	47	42	69	4.93	+.7	9	6,036	s.	27	sw.	3	12	7	11	5.1	T	T
Austin	605	136	148	29.40	30.04		63.6	+5.1	88	2	74	35	30	53	37	55	50	69	5.21	+2.9	9	5,992	s.	31	nw.	27	15	8	7	4.0	.0	.0
Brownsville	57	88	96	29.94	30.00		71.8	+4.6	89	3	80	48	30	64	26	64	61	75	.66	−1.3	6	7,513	se.	30	nw.	29	11	15	4	4.5	.0	.0
Corpus Christi	20	11	78	30.00	30.02	−.05	70.4	+6.1	87	1	77	43	30	64	22	64	61	77	4.11	+2.1	5	7,712	se.	28	n.	29	16	7	7	3.9	.0	.0
Dallas	512	220	227	29.48	30.03		59.6		85	8	68	34	28	51	29	51	44	66	5.01	+2.5	8	8,938	se.	44	w.	27	14	5	11	4.4	.0	.0
Fort Worth	679	92	110	29.31	30.03	−.07	60.2	+4.7	87	8	70	35	28	50	38				2.30	−.3	9	7,214	se.	35	w.	2	16	5	9	3.9	.0	.0
Galveston	54	106	114	30.00	30.06	−.03	67.7	+4.4	82	1	72	45	30	63	21	62	59	76	6.01	+2.7	10	8,034	se.	43	nw.	21	20	5	5	3.1	.0	.0
Houston	138	292	314	29.92	30.07		65.4	+4.4	87	1	73	42	30	58	23				4.93	+1.1	9	9,085	se.	37	s..	2	18	5	7	3.9	.0	.0
Palestine	510	64	72	29.53	30.07	−.04	60.7	+3.5	84	8	70	33	23	51	29	53	48	71	9.27	+5.8	9	5,705	s.	25	sn	19	14	4	12	4.5	.0	.0
Port Arthur	34	58	66	30.02	30.06		64.7		85	1	72	40	23	57	21	58	55	78	5.77	+2.7	9	6,061	e.	32	w.	21	11	14	5	4.6	.0	.0
San Antonio	693	242	301	29.30	30.02	−.06	65.6	+5.3	88	1	75	38	30	56	26	59	55	76	2.88	+1.0	8	8,602	se.	49	w.	21	11	14	5	4.2	.0	.0

TABLE 1.—*Climatological data for Weather Bureau stations, November 1934*—Continued

District and station	Elevation of instruments: Barometer above sea level	Elevation of instruments: Thermometer above ground	Elevation of instruments: Anemometer above ground	Pressure: Station, reduced to mean of 24 hours	Pressure: Sea level, reduced to mean of 24 hours	Pressure: Departure from normal	Temperature of the air: Mean max. + mean min. ÷ 2	Temperature of the air: Departure from normal	Temperature of the air: Maximum	Temperature of the air: Date	Temperature of the air: Mean maximum	Temperature of the air: Minimum	Temperature of the air: Date	Temperature of the air: Mean minimum	Temperature of the air: Greatest daily range	Mean wet thermometer	Mean temperature of the dew point	Mean relative humidity	Precipitation: Total	Precipitation: Departure from normal	Precipitation: Days with 0.01, or more	Wind: Total movement	Wind: Prevailing direction	Wind: Maximum velocity: Miles per hour	Wind: Maximum velocity: Direction	Wind: Maximum velocity: Date	Clear days	Partly cloudy days	Cloudy days	Average cloudiness, tenths	Total snowfall	Snow, sleet, and ice on ground at end of month
Ohio Valley and Tennessee	*Ft.*	*Ft.*	*Ft.*	*In.*	*In.*	*In.*	*°F*	*° F*	*° F*		*°F*	*° F*		*° F*	*° F*	*°F*	*° F*	*%*	*In.*	*In.*		*Miles*								*0–10*	*In.*	*In.*
							49.7	**+4.2**										**67**	**3.05**	**+0.1**										**5.6**		
Chattanooga	762	71	214	29.33	30.15	+0.01	54.0	+3.6	77	8	64	28	13	44	37	46	40	66	2.48	−0.9	8	6,678	se.	37	se.	21	16	7	7	3.9	0.0	0.0
Knoxville	995	66	84	29.07	30.15	+.02	51.6	+3.7	75	30	62	28	16	41	37	44	39	69	1.92	−1.2	8	4,417	e.	28	nw.	5	17	5	8	4.9	.0	.0
Memphis	399	78	86	29.65	30.08	−.04	55.7	+4.0	78	7	54	34	12	47	30	48	41	65	13.21	+9.0	10	5,814	sw.	40	w.	21	14	7	9	4.4	.0	.0
Nashville	546	168	191	29.54	30.14	+.02	53.0	+4.0	78	7	63	31	12	44	33	45	38	61	1.45	−2.0	8	8,189	se.	38	se.	21	11	10	9	4.9	.0	.0
Lexington	989	5																													
Louisville	525	188	234	29.53	30.12		50.3	+3.6	77	21	59	27	15	41	32	43	36	63	1.14	−2.5	7	8,772	s.	41	se.	21	10	10	10	5.2	.0	.0
Evansville	431	76	116	29.61	30.09	−.03	50.9	+4.3	74	21	60	30	15	42	27	44	38	66	2.11	−1.6	8	7,464	s.	39	sw.	30	12	8	10	4.7	.0	.0
Indianapolis	822	194	230	29.19	30.09	−.01	46.7	+4.4	73	21	55	26	14	38	30	41	34	65	2.14	−1.2	12	9,326	s.	35	sw.	30	4	9	17	6.8	T	.0
Terre Haute	575	96	129	29.44	30.07		48.0		72	19	56	27	2	40	27	42	36	69	4.28	+1.0	12	8,139	s.	35	e.	30	11	7	12	5.3	.0	.0
Cincinnati	627	11	51	29.43	30.12	.00	48.4	+5.9	75	21	58	23	2	39	34	41	35	68	1.72	−1.1	9	6,432	s.	27	sw.	30	7	7	16	6.4	T	.0
Columbus	822	216	230	29.22	30.11	.00	47.0	+5.1	73	21	55	24	15	39	30	41	35	68	.92	−1.8	8	9,238	se.	34	w.	7	3	10	17	7.2	T	.0
Elkins	1,947	59	78	28.09	30.19	+.07	44.6	+4.3	71	19	55	13	15	34	43	38	34	76	3.45	+.7	14	5,597	w.	32	w.	7	8	7	15	6.7	.5	.0
Parkersburg	637	77	84	29.50	30.17	+.05	47.4	+3.6	76	22	57	19	15	38	37	41	36	72	2.16	−.4	10	5,260	se.	27	nw.	7	6	10	14	6.2	T	.0
Pittsburgh	842	353	410	29.20	30.13	+.03	46.8	+3.6	73	22	54	25	15	40	29	40	35	68	2.63	+.3	13	6,945	sw.	32	se.	22	8	12	15	7.4	1.7	.0
Lower Lake Region							**44.2**	**+4.9**										**75**	**2.30**	**−0.5**									**8.1**		
Buffalo	768	243	280	29.22	30.06	+.01	43.4	+4.0	69	22	49	24	14	38	27	40	37	78	2.55	−.5	15	11,958	s.	50	sw.	4	2	6	22	8.0	2.9	.0
Canton	448	10	61	29.58	30.06		39.4	+5.5	66	22	46	19	14	33	28				3.29	+1.1	14	6,669	sw.	30	sw.	17	2	5	23	8.5	1.8	.0
Ithaca	836	77	100	29.18	30.10		44.0	+5.4	74	20	50	19	15	38	23	40	36	78	1.93	−.4	15	8,299	se.	34	se.	4	2	4	24	8.5	2.3	.0
Oswego	335	71	85	29.70	30.07	+.02	43.9	+5.0	66	4	50	25	15	38	26	40	36	76	3.00	−.4	16	8,391	s.	32	n.	13	2	1	27	9.0	.9	.0
Rochester	523	86	102	29.50	30.08	+.03	44.2	+5.5	67	22	50	23	15	38	25	40	36	75	2.81	+.3	17	6,571	sw.	25	sw.	4	2	3	25	8.7	1.6	.0
Syracuse	596	65	79	29.44	30.10	+.04	44.9	+6.2	69	20	51	24	14	39	24				2.64	−.1	17	6,037	s.	24	se.	4	2	2	26	8.5	3.6	.0
Erie	714	130	166	29.29	30.07	+.01	46.2	+4.8	72	22	52	27	14	40	28	41	37	74	2.96	−.3	15	11,778	sw.	48	s.	22	3	8	19	7.8	2.6	.0
Cleveland	762	267	337	29.24	30.07	.00	47.0	+6.1	73	22	53	30	15	41	29	41	36	70	1.40	−1.2	16	12,277	s.	47	w.	13	1	6	23	8.1	1.5	.0
Sandusky	629	5	67	29.38	30.08	.00	45.2	+4.1	70	30	52	24	15	38	32				1.01	−1.4	11	7,990	sw.	30	sw.	4	1	11	18	8.0	T	.0
Toledo	628	79	87	29.39	30.08	+.01	44.8	+4.4	69	21	51	25	15	38	31	40	35	73	.96	−1.4	9	7,584	sw.	28	nw.	7	2	11	17	7.3	T	.0
Fort Wayne	857	69	84	29.13	30.07		44.4	+3.8	69	21	51	24	14	38	26	40	36	76	3.36	+.5	14	7,812	sw.	37	sw.	30	3	14	13	7.1	.2	.0
Detroit	626	5	78	29.36	30.06	.00	43.6	+4.3	66	20	50	26	12	37	27	39	36	77	1.67	−.8	12	8,686	sw.	41	nw.	13	0	7	23	8.2	T	.0
Upper Lake Region							**40.3**	**+5.0**										**81**	**4.91**	**+2.5**									**8.3**		
Alpena	609	13	89	29.34	30.02	+.01	39.7	+5.3	58	4	44	26	12	35	24	37	34	84	2.57	.0	17	8,907	nw.	34	se.	26	1	4	25	8.6	2.8	.0
Escanaba	612	54	60	29.33	30.01	−.02	37.4	+4.3	56	5	43	23	2	32	24	35	32	82	5.66	+3.5	13	8,266	nw.	32	n.	13	3	2	25	8.5	1.5	1.0
Grand Rapids	707	70	244	29.24	30.02	−.03	44.2	+5.8	67	21	50	24	14	38	27	40	36	77	3.40	+.6	15	9,255	sw.	38	sw.	30	2	3	25	8.7	.3	.0
Lansing	878	6	88	29.08	30.04		41.7	+4.2	65	20	48	22	14	35	28	39	37	86	2.85	+.4	13	8,117	sw.	30	nw.	13	2	7	21	8.3	T	.0
Ludington	637	5	54	29.30	30.00		42.5	+5.1	63	21	47	27	14	38	18	39			5.54	+2.9	17		se.				2	3	25		2.3	.0
Marquette	734	77	111	29.18	29.99	−.03	36.8	+3.5	57	16	42	23	24	32	23	34	32	85	5.76	+2.8	18	7,719	w.	36	sw.	16	1	5	24	8.5	12.1	2.0
Sault Sainte Marie	614	11	52	29.31	30.02	+.01	37.6	+5.6	55	22	42	22	12	33	22	35	32	83	7.67	+5.0	21	6,976	se.	28	nw.	4	0	4	26	9.2	3.9	.0
Chicago	673	7	131	29.30	30.03	−.04	45.8	+5.7	67	19	52	28	12	40	27	41	36	72	3.87	+1.5	11	8,877	sw.	31	sw.	30	3	10	17	7.5	T	.0
Green Bay	617	109	141	29.32	29.99	−.05	39.8	+5.8	59	16	46	21	12	33	27	36	32	77	6.19	+4.0	11	8,440	sw.	34	ne.	21	2	7	21	8.3	.2	T
Milwaukee	681	97	221	29.26	30.01	−.04	43.2	+5.9	63	16	50	25	12	37	26	39	35	76	8.56	+6.8	12	10,375	w.	44	s.	30	4	6	20	7.6	T	.0
Duluth	1,133	5	47	28.75	30.00	−.04	34.2	+4.2	64	6	41	19	23	28	30	31	29	87	1.90	+.4	8	9,273	nw.	36	nw.	6	3	6	21	7.9	4.2	2.4
North Dakota							**34.2**	**+7.4**										**76**	**0.25**	**−0.5**									**5.6**		
Moorhead, Minn	940	50	58	28.98	30.02	−.05	34.2	+7.1	68	16	42	11	22	26	40	30	27	80	.54	−.4	6	6,114	s.	22	nw.	9	4	14	12	6.7	.6	T
Bismarck	1,674	8	57	28.18	30.01	−.06	35.9	+7.4	67	12	46	13	30	26	40	30	24	69	.20	−.4	4	5,331	e.	22	ne.	16	12	8	10	5.3	T	.0
Devils Lake	1,478	11	44	28.41	30.03	−.03	32.0	+7.5	63	16	40	8	22	24	31	28	25	85	.25	−.5	5	6,258	se.	27	nw.	6	9	8	13	6.2	.7	T
Grand Forks	833	12	67				32.0		63	16	40	7	23	24	34	29			.65		4		nw.	30	nw.	6	12	4	14		2.2	.2
Williston	1,878	41	48	27.97	30.00	−.06	34.8	+7.6	68	15	46	8	28	23	42	29	23	70	.02	−.6	2	4,876	se.	30	w.	8	15	6	9	4.4	.1	.0
Upper Mississippi Valley							**44.6**	**+6.0**										**76**	**5.68**	**+3.6**									**6.1**		
Minneapolis	918	102	208	28.99	29.99		38.8	+6.4	70	6	45	21	23	32	31	35	30	74	2.38	+1.1	7	8,149	nw.	32	n.	30	5	7	18	7.3	8.5	8.0
La Crosse	714	11	48	29.21	30.00	−.07	40.4	+5.2	65	6	47	23	12	34	33	37	33	81	7.01	+5.4	12	4,443	nw.	18	nw.	22	4	8	18	7.4	15.5	9.5
Madison	974	70	78	28.93	30.00	−.06	41.6	+6.4	61	16	48	26	12	35	25	38	35	83	7.86	+6.1	13	7,353	nw.	85	ne.	30	7	6	17	7.0	.2	.2
Charles City	1,015	10	51	28.91	30.01	−.07	39.6	+6.6	66	6	47	20	23	32	34	36	33	80	5.52	+4.0	14	5,819	se.	24	n.	30	7	6	17	6.5	16.3	14.0
Davenport	606	66	161	29.36	30.02	−.06	45.3	+6.3	68	18	53	25	1	38	29	41	37	78	6.48	+4.7	14	7,537	sw.	34	sw.	30	7	10	13	6.3	T	T
Des Moines	861	5	99	29.10	30.02	−.06	42.9	+4.5	71	19	51	19	23	35	33	39	36	80	4.08	+2.6	14	7,414	se.	30	n.	22	11	3	16	6.1	6.4	5.6
Dubuque	700	60	79	29.24	30.00	−.07	43.3	+6.3	65	20	50	25	23	36	33	39	35	77	8.63	+6.9	14	5,962	s.	19	nw.	5	6	8	16	6.6	T	.4
Keokuk	614	64	78	29.35	30.03	−.06	46.8	+5.7	73	19	55	26	23	39	28	41	36	73	4.86	+2.9	16	6,379	sw.	27	sw.	30	12	3	15	5.8	T	.0
Cairo	358	87	93	29.69	30.08	−.04	52.6	+5.3	76	7	61	33	12	44	29	45	39	67	8.45	+4.8	9	7,283	s.	32	sw.	30	13	6	11	4.8	.0	.0
Peoria	609	11	45	29.37	30.04	−.05	46.0	+8.5	71	19	54	24	12	38	31	41	38	79	4.81	+2.4	15	6,154	s.	28	sw.	30	14	6	10	4.9	.0	.0
Springfield, Ill	636	5	191	29.35	30.03	−.07	48.0	+5.8	73	18	56	28	15	40	27	42	38	74	5.38	+2.9	12	9,529	s.	42	s.	30	11	6	13	5.7	.0	.0
St. Louis	568	265	303	29.43	30.04	−.06	50.4	+5.3	76	7	59	31	23	42	30	44	38	68	2.66	−.2	8	10,232	s.	43	sw.	30	15	6	9	4.7	T	.0
Missouri Valley							**45.4**	**+5.5**										**73**	**3.29**	**+1.8**									**5.1**		
Columbia, Mo	784	6	84	29.18	30.03	−.06	48.8	+5.5	77	7	58	25	23	40	35				4.40	+2.2	12	6,779	se.	28	sw.	18	12	10	8	4.9	1.9	1.4
Kansas City	750	32	45	29.20	30.02	−.07	48.0	+4.3	78	7	57	22	23	39	36	43	39	77	5.40	+3.6	13	6,833	sw.	42	n.	21	11	6	13	5.7	5.0	2.0
St. Joseph	967	11	49	28.96	30.01		46.8		73	6	55	25	23	38	30	41	37	76	5.22	+3.6	11	6,371	se.	32	n.	21	12	4	14	5.4	6.1	4.2
Springfield, Mo	1,324	98	104	28.62	30.04	−.06	49.8	+4.1	78	7	58	27	30	41	27	43	38	70	5.70	+2.9	12	8,157	se.	31	se.	20	17	6	7	3.9	15.6	11.0
Iola	984	11	50	28.96	30.02	−.07	50.0	+5.9	78	7	60	27	1	40	39				5.03	+3.2	13						12	7	11		4.7	T
Topeka	987	65	87				47.7	+4.9	80	6	57	27	23	39	35				2.65	+1.1	12	6,867	s.	36	nw.	21	14	5	11	5.1	4.5	2.3
Lincoln	1,189	11	81	28.72	30.01	−.07	44.4	+5.3	77	6	53	23	1	36	32	39	35	75	2.26	+1.2	7	6,951	s.	30	n.	21	12	5	13	5.5	.2	.1
Omaha	1,105	170	200	28.82	30.03	−.05	43.8	+5.3	76	6	52	23	22	36	33	39	34	74	2.68	+1.6	9	8,166	s.	35	n.	21	13	3	14	5.5	1.8	1.5
Valentine	2,598	47	54	27.28	30.05	−.03	40.5	+5.9	76	15	52	15	30	28	46	33	26	67	.08	−.5	3	5,263	w.	30	sw.	1	11	7	12	5.0	.4	.0
Sioux City	1,138	64	106	28.78	30.02	−.06	41.8	+6.6	76	6	50	21	22	33	37	37	32	74	2.00	+1.0	7	6,585	nw.	30	nw.	21	11	4	15	6.0	T	.0
Huron	1,306	60	74	28.61	30.04	−.04	38.8	+7.3	74	6	48	15	22	29	38	33	28	74	.74	+.2	7	6,205	n.	23	n.	21	16	4	10	4.3	.5	.0
Northern Slope							**38.9**	**+6.2**										**68**	**0.40**	**−0.3**									**5.4**		
Billings	3,140	4																													
Havre	2,505	11	67	27.29	29.97	−.06	38.0	+6.8	71	15	50	8	22	26	42	32	26	72	.13	−.5	4	5,950	sw.	38	sw.	5	14	9	7	4.7	1.0	.0
Helena	4,124	85	111	25.74	29.98	−.12	39.4	+6.2	66	6	47	22	21	32	28	35	30	78	.31	−.4	4	5,198	sw.	30	sw.	2	3	7	20	7.3	.2	.0
Kalispell	2,973	48	56	26.89	29.98	−.09	39.0	+6.6	63	5	44	27	29	34	27	36	34	85	.97	−.4	17	3,431	nw.	23	sw.	5	3	4	23	8.3	3.6	T
Miles City	2,371	48	55	27.44	30.04	−.03	40.2	+9.3	72	6	52	20	30	28	42	33	26	65	.38	−.2	2	3,831	s.	22	w.	6	11	12	7	5.0	T	.0
Rapid City	3,259	50	58	26.59	30.06	−.02	42.7	+6.8	74	6	54	18	22	31	40	34	27	64	.39	−.1	3	4,845	w.	24	ne.	8	13	12	5	4.7	T	.0
Cheyenne	6,094	50	71	23.98	30.03	−.04	39.3	+4.5	71	6	51	13	22	28	39	29	19	50	.10	−.4	3	7,951	w.	33	w.	5	10	11	9	4.9	1.1	.0
Lander	5,372	60	68	24.64	30.09	−.01	35.3	+5.0	69	6	48	−1	30	22	41	28	22	66	.71	+.1	4	3,345	sw.	29	s.	18	9	17	4	4.4	11.3	3.8
Sheridan	3,790	10	47	26.06	30.02		39.5		73	6	53	14	22	26	47	31	25	68	.25	−.4	5	2,929	nw.	22	nw.	2	13	9	8	4.6	1.9	.0
Yellowstone Park	6,241	11	48		30.09	−.02	34.6	+5.3	61	11	44	11	28	26	32			69	.56	−.7	13	5,939	s.	30	sw.	5	6	5	19		9.3	3.0
North Platte	2,821	11	51	27.05	30.03	−.05	42.0	+5.4	79	6	55	18	30	29	45	34	27	67	.17	−.3	3	5,063	w.	26	nw.	3	13	7	10	5.2	.1	T

TABLE 1.—*Climatological data for Weather Bureau stations, November 1934*—Continued

District and station	Elevation of instruments: Barometer above sea level	Elevation of instruments: Thermometer above ground	Elevation of instruments: Anemometer above ground	Pressure: Station, reduced to mean of 24 hours	Pressure: Sea level, reduced to mean of 24 hours	Pressure: Departure from normal	Temperature of the air: Mean max. + mean min. ÷ 2	Temperature of the air: Departure from normal	Temperature of the air: Maximum	Temperature of the air: Date	Temperature of the air: Mean maximum	Temperature of the air: Minimum	Temperature of the air: Date	Temperature of the air: Mean minimum	Temperature of the air: Greatest daily range	Mean wet thermometer	Mean temperature of the dew point	Mean relative humidity	Precipitation: Total	Precipitation: Departure from normal	Precipitation: Days with .01, or more	Wind: Total movement	Wind: Prevailing direction	Wind: Maximum velocity: Miles per hour	Wind: Maximum velocity: Direction	Wind: Maximum velocity: Date	Clear days	Partly cloudy days	Cloudy days	Average cloudiness, tenths	Total snowfall	Snow, sleet, and ice on ground at end of month
	Ft.	Ft.	Ft.	In.	In.	In.	°F	°F	°F		°F	°F		°F	°F	°F	°F	%	In.	In.		Miles								0–10	In.	In.
Middle Slope							47.7	+4.9										63	1.71	+0.7										4.8		
Denver	5,292	106	113	24.71	30.01	−0.05	44.4	+4.6	79	6	55	14	27	34	35	34	21	45	0.61	+0.1	5	5,655	s.	30	w.	4	12	8	10	4.9	3.9	1.0
Pueblo	4,685	80	86	25.28	30.01	−.04	45.2	+5.8	81	6	59	14	29	31	47	34	22	47	.23	−.1	2	4,858	nw.	35	nw.	2	13	14	3	3.9	T	.0
Concordia	1,392	50	58	28.54	30.04	−.04	46.4	+5.0	78	7	56	23	1	37	34	40	36	75	2.29	+1.3	7	6,249	s.	27	ne.	21	12	7	11	5.2	.6	.0
Dodge City	2,509	10	86	27.40	30.03	−.04	47.4	+4.8	81	6	59	22	29	36	41	39	33	68	.98	+.2	6	8,840	s.	35	nw.	27	18	6	6	3.4	3.4	.6
Wichita	1,358	85	93	28.56	30.00	−.08	49.6	+4.8	80	7	58	28	30	41	33	44	39	72	2.90	+1.5	6	8,174	s.	29	nw.	21	10	6	14	5.7	.2	.0
Oklahoma City	1,214	10	47	28.73	30.02	−.06	53.4	+4.6	82	9	63	30	30	44	32	46	41	73	3.23	+1.4	9	7,544	s.	30	n.	21	8	9	13	5.8	T	.0
Southern Slope							56.8	+5.0										59	1.37	+0.3										3.7		
Abilene	1,738	10	52	28.20	30.02	−.05	59.4	+5.9	89	7	70	32	30	49	39	49	41	60	2.45	+1.1	6	7,177	s.	28	s.	17	16	8	6	3.8	.2	.0
Amarillo	3,676	10	49	26.27	30.02	−.03	51.2	+5.7	86	7	63	23	30	40	37	40	32	59	1.13	+.2	7	6,628	sw.	28	nw.	27	13	7	10	4.8	.9	.0
Big Spring	2,537	5	62	27.40	30.03	------	57.0	------	85	7	68	28	30	46	40	46	38	62	2.05	------	5	------	s.	------	------	------	14	10	6	3.5	2.2	.0
Del Rio	944	64	71	29.00	29.98	−.07	64.2	+4.2	87	1	74	34	30	54	36	54	47	60	.11	−1.1	3	6,705	se.	34	w.	21	18	6	6	3.3	.0	.0
Roswell	3,566	75	85	26.39	30.01	−.02	52.2	+4.1	85	7	66	24	29	39	48	41	31	53	1.80	+1.0	6	5,518	s.	32	nw.	21	18	7	5	3.1	.2	T
Southern Plateau							51.2	+1.9										56	0.66	+0.2										3.1		
El Paso	3,778	152	175	26.22	30.01	+.01	55.4	+2.7	82	9	67	27	29	44	36	43	32	47	.21	−.3	1	6,459	nw.	40	w.	20	23	6	1	1.9	.0	.0
Albuquerque	4,972	5	39	25.08	30.04	------	44.4	------	76	7	58	14	29	31	44	36	30	66	.84	+.4	9	5,138	n.	38	nw.	2	11	13	6	4.5	3.0	T
Santa Fe	7,013	38	53	23.26	30.06	+.03	39.8	+.9	70	9	50	3	30	29	32	32	25	63	1.47	+.8	7	4,350	n.	23	nw.	2	12	12	6	4.7	10.2	4.5
Flagstaff	6,907	10	59	23.36	30.01	−.01	38.8	+4.2	72	6	53	12	21	24	45	31	----	69	.49	------	6	5,760	n.	30	n.	28	8	15	7	----	T	.0
Phoenix	1,108	10	107	28.82	29.98	.00	61.4	+1.7	93	6	76	32	30	47	40	48	36	47	.63	−.1	3	3,712	e.	23	n.	28	18	7	5	3.3	.0	.0
Yuma	141	9	54	29.84	29.98	.00	63.8	+1.4	92	6	78	40	22	50	39	51	39	45	.54	+.2	3	3,663	ne.	26	n.	28	23	6	1	2.0	.0	.0
Independence	3,957	5	26	26.02	30.09	+.04	47.7	+.5	71	3	60	26	25	35	40	38	----	----	.27	.0	3	------	n.	----	----	----	20	3	7	2.0	.0	.0
Middle Plateau							43.1	+3.9										60	1.17	+0.4										5.1		
Reno	4,527	61	76	25.51	30.07	−.04	44.9	+3.9	74	6	56	20	28	33	38	38	30	59	.38	−.3	6	4,834	w.	32	w.	30	10	10	10	5.2	T	.0
Tonopah	6,090	12	20	------	------	------	43.6	------	65	6	52	20	28	35	24	35	26	54	.03	------	2	------	se.	------	------	------	----	----	----	----	----	----
Winnemucca	4,344	18	56	25.66	30.09	−.05	42.4	+4.0	73	11	56	15	28	29	45	35	29	68	1.28	+.6	12	5,619	sw.	28	nw.	1	8	10	12	5.7	5.5	2.1
Modena	5,473	10	46	24.65	30.04	−.04	41.0	+4.6	73	6	55	13	30	27	45	32	23	58	.28	−.3	5	7,087	sw.	36	nw.	19	12	10	8	4.5	1.5	.0
Salt Lake City	4,360	86	210	25.67	30.08	−.04	44.2	+3.1	68	15	52	20	30	36	26	38	32	66	2.89	+1.5	12	4,614	se.	29	w.	2	10	7	13	5.6	7.4	3.5
Grand Junction	4,602	60	68	25.42	30.04	−.04	43.2	+3.9	72	10	54	20	27	32	35	34	25	56	1.04	+.5	10	4,021	se.	29	nw.	2	10	13	7	4.6	3.0	.1
Northern Plateau							44.4	+5.4										73	1.81	+0.4										7.5		
Baker	3,471	48	53	26.44	30.05	−.11	41.9	+5.9	66	7	50	18	28	34	32	37	33	73	1.02	.0	15	5,295	se.	23	sw.	1	3	12	15	6.9	6.2	2.1
Boise	2,739	79	87	27.20	30.09	−.08	46.6	+5.6	72	14	55	25	28	38	31	41	35	68	1.97	+.7	13	4,105	se.	24	se.	30	6	7	17	6.8	.3	.0
Pocatello	4,477	60	68	25.50	30.06	−.08	42.2	+5.5	69	7	50	23	27	34	36	35	30	67	2.14	+1.2	14	7,030	se.	31	sw.	2	8	9	13	6.1	10.4	2.0
Spokane	1,929	101	110	27.92	29.98	−.12	43.6	+5.1	64	5	49	27	28	38	24	40	38	81	2.01	−.1	17	5,034	s.	25	s.	5	3	4	23	8.2	1.0	T
Walla Walla	991	57	65	28.91	29.99	−.14	48.9	+6.1	77	5	54	37	23	44	28	44	39	70	2.38	+.4	16	4,655	s.	24	w.	30	0	8	22	8.7	.0	.0
Yakima	1,076	58	67	28.83	29.99	------	43.4	+4.5	66	5	51	26	29	36	26	40	37	80	1.36	+.5	13	3,169	nw.	24	w.	25	3	4	23	8.2	.2	.0
North Pacific Coast Region							50.4	+3.9										84	8.62	+2.2										8.7		
North Head	211	11	56	29.68	29.91	−.14	50.5	+2.3	63	11	54	40	26	47	12	49	47	87	10.18	+1.7	24	13,304	s.	68	s.	2	0	6	24	8.8	.0	.0
Seattle	125	90	321	29.77	29.90	−.14	50.0	+4.4	64	11	54	39	10	46	23	47	44	80	6.67	+1.6	24	7,980	se.	37	sw.	5	1	6	23	8.1	.0	.0
Tatoosh Island	86	10	54	29.75	29.85	−.12	49.8	+3.9	60	11	52	41	26	47	11	48	46	88	13.50	+1.6	26	12,584	e.	65	s.	5	0	2	28	9.4	.0	.0
Medford	1,329	29	58	28.63	30.06	------	46.8	------	74	5	55	30	28	38	34	44	41	82	3.44	+1.0	21	3,481	nw.	30	se.	14	4	1	25	8.4	.0	.0
Portland, Oreg.	153	68	106	29.81	29.96	−.14	50.3	+3.5	68	5	55	39	16	46	19	47	45	84	10.47	+4.4	24	5,197	se.	23	s.	5	2	3	25	8.8	.0	.0
Roseburg	510	45	76	29.47	30.03	−.09	51.4	+5.5	76	5	58	36	26	45	25	48	45	83	7.47	+2.8	23	3,050	sw.	18	nw.	30	2	3	25	8.6	.0	.0
Middle Pacific Coast Region							55.9	+2.2										80	5.00	+1.8										6.9		
Eureka	62	73	89	30.02	30.09	−.02	54.0	+2.9	74	5	60	37	26	48	20	51	49	86	8.63	+3.4	21	5,177	se.	31	nw.	30	4	7	19	7.6	.0	.0
Redding	722	20	34	------	------	------	53.6	------	79	9	61	40	24	46	29	48	44	74	8.34	------	15	4,597	nw.	27	s.	14	4	7	19	7.6	.0	.0
Sacramento	69	92	115	30.02	30.09	.00	55.2	+1.6	74	6	64	38	24	47	27	51	48	79	2.61	+.7	8	5,019	se.	29	se.	18	5	16	9	5.9	.0	.0
San Francisco	155	208	243	29.93	30.10	+.01	58.5	+2.2	75	6	64	49	28	53	20	54	51	81	3.76	+1.4	10	4,020	w.	26	s.	18	6	9	15	6.6	.0	.0
South Pacific Coast Region							59.8	+1.6										73	2.32	+1.4										4.7		
Fresno	327	97	105	29.75	30.12	+.06	55.5	+1.3	78	6	64	35	30	47	27	52	48	80	2.22	+1.3	5	3,192	nw.	16	e.	18	7	12	11	5.7	.0	.0
Los Angeles	338	159	191	29.68	30.05	+.03	62.8	+1.9	89	5	71	50	25	55	27	53	46	64	2.79	+1.6	6	4,036	ne.	23	nw.	24	15	8	7	4.0	.0	.0
San Diego	87	62	70	29.94	30.03	+.01	61.2	+1.5	82	6	69	47	28	54	24	55	51	76	1.95	+1.2	5	3,980	nw.	22	s.	19	12	13	5	4.4	.0	.0
West Indies																																
San Juan, P. R.	82	9	54	29.81	29.89	------	78.0	−.4	86	14	84	69	27	73	16	----	----	----	6.74	.0	19	6,157	s.	36	e.	9	7	21	2	4.8	.0	.0
Panama Canal																																
Balboa Heights	118	6	97	------	[1] 29.82	+.01	78.6	−.5	87	4	84	70	26	73	15	----	----	[1] 89	12.89	+2.5	25	3,335	nw.	24	s.	16	0	6	24	8.2	.0	.0
Cristobal	36	6	97	------	[1] 29.86	+.03	79.6	+.3	88	5	85	72	27	75	13	75	75	[1] 86	28.81	+6.9	28	4,532	w.	27	ne.	11	0	6	24	8.2	.0	.0
Alaska																																
Fairbanks	454	11	87	[1] 29.21	[2] 29.77	------	1.3	------	34	1	8	−19	25	−5	19	2	−2	79	.14	------	5	2,579	n.	12	ne.	14	14	6	10	4.8	7.1	3.5
Juneau	80	96	116	[1] 29.54	[2] 29.63	------	36.8	------	52	10	40	24	23	33	12	34	30	78	5.57	------	18	5,342	s.	41	se.	10	4	3	23	8.0	.8	.0
Hawaiian Islands																																
Honolulu	38	86	100	[1] 29.98	[2] 30.02	------	76.3	+1.8	85	1	80	67	28	72	13	70	68	77	2.49	−1.4	17	6,567	e.	26	sw.	28	10	14	6	4.7	.0	.0

[1] Observations taken bihourly.

[2] Pressure not reduced to mean 24 hours.

TABLE 2.—*Data furnished by the Canadian Meteorological Service, November 1934*

Stations	Altitude above mean sea level Jan. 1, 1919	Pressure			Temperature of the air						Precipitation		
		Station reduced to mean of 24 hours	Sea level reduced to mean of 24 hours	Departure from normal	Mean max. + mean min. ÷ 2	Departure from normal	Mean maximum	Mean minimum	Highest	Lowest	Total	Departure from normal	Total snowfall
	Feet	*In.*	*In.*	*In.*	*°F.*	*°F.*	*°F.*	*°F.*	*°F.*	*°F.*	*In.*	*In.*	*In.*
Cape Race, Newfoundland	99												
Sydney, Cape Breton Island	48	30.04	30.09	+0.14	41.6	+4.5	47.9	35.2	62	24	6.50	+1.06	0.0
Halifax, Nova Scotia	88	29.86	29.97	−.04	41.4	+4.1	47.3	35.5	59	21	11.96	+6.30	T
Yarmouth, Nova Scotia	65	29.99	30.06	+.04	42.7	+2.8	48.4	37.0	60	24	7.52	+3.03	T
Charlottetown, Prince Edward Island	38												
Chatham, New Brunswick	28	29.95	29.98	+.01	33.8	+2.8	41.6	26.1	65	10	4.29	+.54	9.6
Father Point, Quebec	20	30.02	30.04	+.08	31.8	+2.9	37.2	26.4	56	6	2.20	−.91	13.2
Quebec, Quebec	296	29.76	30.10	+.08	33.6	+4.6	37.8	29.5	54	18	5.07	+1.31	11.1
Doucet, Quebec	1,236				28.2		35.9	20.4	54	0	1.57		1.1
Montreal, Quebec	187												
Ottawa, Ontario	236	29.81	30.08	+.06	37.9	+6.2	44.3	31.5	62	20	3.28	+.74	6.3
Kingston, Ontario	285	29.75	30.07	+.03	40.7	+5.7	46.1	35.3	60	21	4.28	+1.04	.2
Toronto, Ontario	379	29.64	30.06	+.02	42.1	+6.5	47.6	36.6	62	25	3.10	−.04	T
Cochrane, Ontario	930				29.0		34.1	23.9	54	9	3.77		10.8
White River, Ontario	1,244	28.65	30.00	+.02	28.4	+7.9	34.2	22.6	50	3	3.08	+1.23	9.7
London, Ontario	808				40.9		47.4	34.4	63	20	4.68		10.8
Southampton, Ontario	656	29.31	30.04	+.02	40.7	+5.7	46.4	35.0	62	24	3.81	+.11	2.1
Parry Sound, Ontario	688	29.32	30.02	+.01	38.2	+6.1	43.2	33.3	57	20	4.62	+.25	5.6
Port Arthur, Ontario	644	29.29	30.02	+.02	32.2	+8.2	38.1	26.3	56	8	1.97	+.64	9.1
Winnipeg, Manitoba	760	29.17	30.04	.00	29.8	+11.8	35.9	23.7	55	7	.78	−.30	5.2
Minnedosa, Manitoba	1,690	28.14	30.01	−.03	27.9	+10.6	35.7	20.2	58	0	.34	−.66	3.0
Le Pas, Manitoba	860		30.05		21.9		27.8	16.0	47	−16	2.06		20.0
Qu'Appelle, Saskatchewan	2,115	27.63	29.93	−.07	28.0	+9.2	36.7	19.4	60	−6	.31	−.58	2.8
Moose Jaw, Saskatchewan	1,759				30.8		41.1	20.6	69	2	.10		.5
Swift Current, Saskatchewan	2,392	27.32	29.88	−.14	32.8	+9.6	43.8	21.8	70	−1	.17	−.52	.0
Medicine Hat, Alberta	2,365	27.32	29.83	−.17	34.6	+7.2	44.6	24.6	72	−4	.67	−.25	4.3
Calgary, Alberta	3,540	26.14	29.87	−.11	32.3	+6.5	42.4	22.1	68	0	.26	−.62	2.6
Banff, Alberta	4,521												
Prince Albert, Saskatchewan	1,450	28.40	30.02	−.01	24.3	+8.9	30.3	18.2	46	−6	.91	+.08	8.2
Battleford, Saskatchewan	1,592	28.17	29.97	−.05	24.2	+7.9	33.3	15.1	54	−5	.44	−.14	3.4
Edmonton, Alberta	2,150	27.56	29.90	−.07	25.1	+2.2	33.2	17.1	58	−4	.46	−.12	3.9
Kamloops, British Columbia	1,262	28.63	29.94	−.02	41.5	+8.1	46.7	36.2	64	27	.47	−.99	1.8
Victoria, British Columbia	230	29.61	29.86	−.13	47.8	+4.6	51.0	44.7	56	41	4.58	−2.39	.0
Barkerville, British Columbia	4,180												
Estevan Point, British Columbia	20												
Prince Rupert, British Columbia	170												
Hamilton, Bermuda	151												

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Edmonton, Alberta	2,150	27.65	29.95	+0.02	42.0	+0.9	53.6	30.5	80	14	0.20	−0.50	0.8
Hamilton, Bermuda	151	29.83	29.99	−.03	74.9	+1.9	79.8	70.1	88	64	2.73	−3.98	.0

SEVERE LOCAL STORMS, NOVEMBER 1934

[Compiled by Grace W. Carter]

[The table herewith contains such data as have been received concerning severe local storms that occurred during the month. A revised list of tornadoes will appear in the Annual Report of the Chief of Bureau]

Place	Date	Time	Width of path (yards)	Loss of life	Value of property destroyed	Character of storm	Remarks	Authority
Gaffney, S. C., vicinity of	1	A. m.			15,000	Electrical	Humphries Gin Co.'s plant destroyed and watchman shocked by lightning.	Official, U. S. Weather Bureau.
Orangeburg, S. C.	1	4 p. m.			500	Hail and wind	Power and telephone lines blown down; trees uprooted; property damaged.	Do.
Port Arthur (near), Tex.	2	8 p. m.	33		75,000	Tornado	Buildings, telegraph and telephone lines damaged; path 6 miles long.	Do.
San Antonio, Tex. (10 miles northwest of).	3		13			Probably tornado	Dairy building wrecked; 2 persons injured	Do.
Glacier and Toole Counties, Mont.	5				13,500	Wind	Oil field property damaged; overhead wires and poles blown down.	Do.
Newberry County, S. C. (Mount Pilgrim section).	10				1,050	Electrical	Barn and contents destroyed by lightning	Do.
Wellington, Kans	17	8:18 p. m.	200		60,000	Tornado	Chief damage to Sante Fe Ry. property; number of houses damaged and small buildings demolished; 2 persons injured.	Do.
Winnetka, Ill., and vicinity	18	8:30 p. m.				Thundersquall and rain.	Transformers of the Public Service Co. of North Illinois put out of commission, city in darkness for about an hour. Several automobiles overturned, and chimneys wrecked.	Chicago Tribune.
Compton, Ill.	18				4,000	Wind	Property damaged	Official, U. S. Weather Bureau.
Dallas City (near), Ill.	18			3		Squall	Boat capsized in Mississippi River	Do.
Kewanee, Ill.	18		167		1,000	Tornado	Some property damage; 3 persons injured; path 2 miles long.	Do.
Rapid City (near), Ill.	18		50		3,000	do	Property damaged; path 1 mile long	Do.
Steffenville, Mo. (3 miles east of)	19	7:30 p. m.			3,000	Wind	A number of buildings wrecked	Do.
Mount Pleasant, Tex. (Greenhill Community).	19	8 p. m.	75	1	4,000	Tornado	Buildings damaged; 1 person injured; path 3 miles long.	Do.
Milwaukee, Wis.	19					Rain, floods, electrical.	Streets and basements flooded; building damaged by lightning.	Do.
McGehee (near), Ark.	20	3:20 a. m.		2	10,000	Tornado	Barns and tenant houses destroyed; fences and trees blown down; 1 person injured.	Do.
Woodville, Tex.	20	a. m.				Probably tornado	5 homes unroofed; trees uprooted	Do.
Minden, La.	20	3:30-4 p.m.	[1] 3		25,000	Hail	Skylights, roofs, and auto tops damaged, path 10 miles long.	Do.
Crossett, Ark. (8 miles northwest of).	20	p. m.			5,000	Tornado	Several barns and small buildings wrecked; 2 dwellings blown from foundations.	Do.
Shelby County, Tenn.	20-21				5,000	Heavy rain and wind.	Telephone and electric service crippled; traffic impeded; roads and bridges washed out; several families rescued from flooded areas in Memphis.	Do.
Red River Parish, La. (southern).	21	1 a. m.	[1] 5		4,500	Thundersquall	Damage chiefly to buildings; path 5 miles long	Do.
Pensacola (near), Fla.	21	11:30 p. m.	50		2,000	Tornadic wind	Roofs damaged and a few trees uprooted; path 1 mile long.	Do.
McGehee, Ark., and vicinity	27	1:15 p. m.			3,000	Tornado	2 small buildings demolished and many damaged	Do.
Jackson, Mo.	27	7 p. m.				Wind	Buildings damaged; loss not estimated	Do.
Granville, Vance, Warren, Franklin, Wake, and Durham Counties, N. C.	28-30					Heavy rains	Land washed; roadways badly damaged; many bridges carried away.	Do.
Port Allen, La.	29	4 p. m.	17		1,200	Tornado	Buildings damaged; 6 persons injured; path 1 mile long.	Do.
Hammond (near), La.	29	4-5 p. m.				Wind	Damage unestimated; 1 person injured	Do.
Newton (near) and Laurel, Miss.	29	8:15 p. m.				Thundersqualls	36 persons injured and 16 houses blown down	Do.
Learned, Miss.	29	P. m.		1		Probably tornado	Dwelling demolished; 5 persons injured, 1 of whom died later.	Do.
Iowa	29-30					Heavy snow and wind.	Highways and city streets obstructed causing delay in transportation; thousands of motor vehicles abandoned; telephone service interrupted.	Do.
Central and southwestern Missouri.	29-30			3	300,000	Heavy snow	Heavy loss to telephone and electric companies; traffic paralyzed; trees broken; second heaviest snow of record at Springfield.	Do.
Virginia	29-30					Heavy rains	Statement of damage to be given in a later report	Do.
Clay County, Ind.	30			1		Wind	Small building blown down	Do.
Port Washington to Milwaukee, Wis.	30				5,500	do	Heavy seas caused waterfront property damage; considerable damage to roofs, windows and overhead wires; navigation on Lake Michigan greatly impeded.	Do.
Southeastern counties, Minn.	30					Wind and snow	Traffic seriously delayed	Do.

LATE REPORTS, OCTOBER 1934

Logan, Iowa	23	7:30 p. m.				Tornado	Farm buildings damaged and trees uprooted; 1 person injured.	Official, U. S. Weather Bureau.
Cairo, Ill.	31				5,700	Wind and hail	No details of damage	Do.

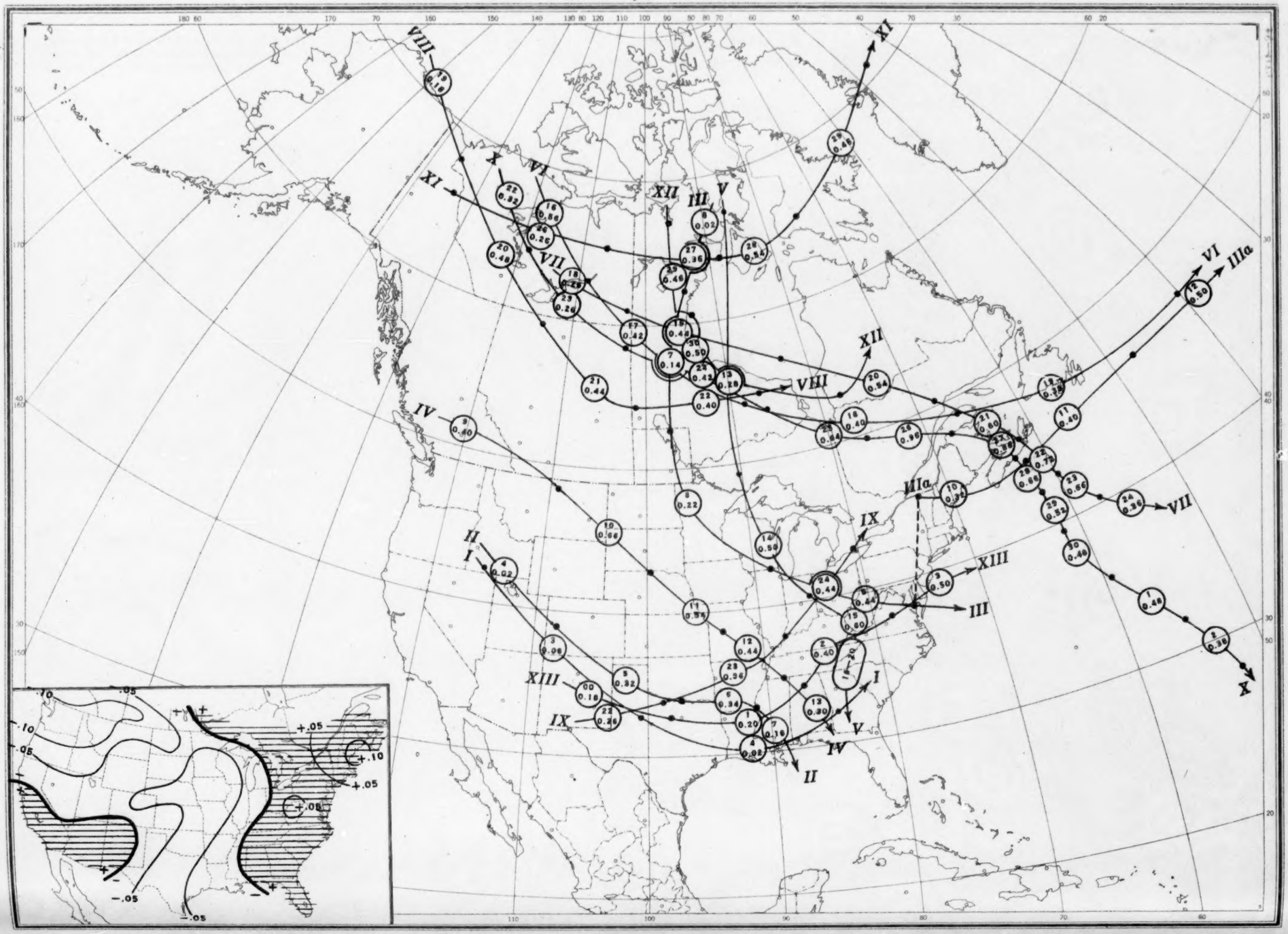
NOTE.—See p. 2 of cover for correction.

Chart I. Departure (°F.) of the Mean Temperature from the Normal, November 1934

Chart I. Departure (°F.) of the Mean Temperature from the Normal, November 1934

Chart II. Tracks of Centers of Anticyclones, November 1934. (Inset) **Departure of Monthly Mean Pressure from Normal**

(Plotted by G. E. Dunn)



Circle indicates position of anticyclone at 8 a. m. (75th meridian time), with barometric reading. Dot indicates position of anticyclone at 8 p. m. (75th meridian time).

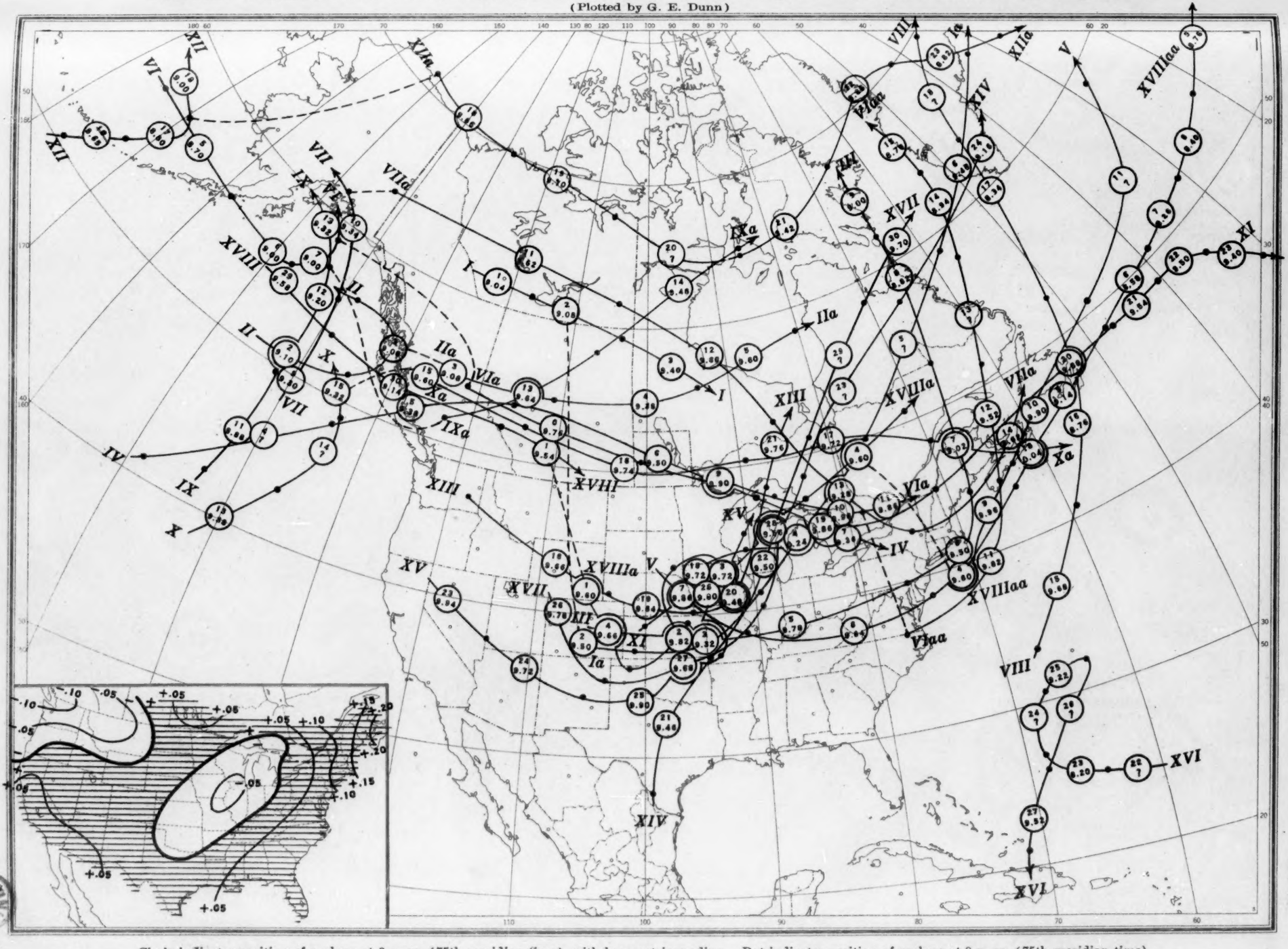
Chart III. Tracks of Centers of Cyclones, November 1934. (Inset) **Change in Mean Pressure from Preceding Month**

(Plotted by G. E. Dunn)

Circle indicates position of anticyclone at 8 a. m. (75th meridian time), with barometric reading. Dot indicates position of anticyclone at 8 p. m. (75th meridian time).

Chart III. Tracks of Centers of Cyclones, November 1934. (Inset) **Change in Mean Pressure from Preceding Month**

(Plotted by G. E. Dunn)



Circle indicates position of cyclone at 8 a. m. (75th meridian time), with barometric reading. Dot indicates position of cyclone at 8 p. m. (75th meridian time).

Chart IV. Percentage of Clear Sky Between Sunrise and Sunset, November 1934

4 a.m.
5 a.m.
6 a.m.
7 a.m.
8 a.m.
9 a.m.
Barkerville
Edmonton
Kamloops
Medicine Hat
Qu'Appelle
Swift Current
Minnedosa
The Pas
Prince Albert
Battleford
Calgary
Winnipeg
White River
Cochrane
Sault Ste. Marie
Stonecliffe
Parry Sound
Southampton
Port Huron
Father Point
Chatham
Quebec
Rapid City
Sioux City
Omaha
North Platte
Lincoln
Concordia
St. Joseph
Topeka
Kansas City
Columbia
St. Louis
Springfield
Cairo
Dodge City
Wichita
Oklahoma
Fort Smith
Little Rock
Memphis
Nashville
Knoxville
Asheville
Charlotte
Atlanta
Augusta
Charleston
Macon
Savannah
Birmingham
Montgomery
Meridian
Jackson
Mobile
Pensacola
Tallahassee
Jacksonville
Tampa
Miami
Key West
Havana
Cienfuegos
Santiago de Cuba
Bermuda
Cape Henry
Hatteras
Cape May
Atlantic City
Sandy Hook
Block Island
Portland
Eastport
Yarmouth
Amherst
Dalhousie
Rimouski
Quebec
Father Point
Chatham
Stonecliffe
Sault Ste. Marie
Parry Sound
Southampton
Port Huron
Toledo
Detroit
Cleveland
Buffalo
Erie
Pittsburgh
Harrisburg
Philadelphia
New York
Boston

Chart V. Total Precipitation, Inches, November 1934. (Inset) Departure of Precipitation from Normal

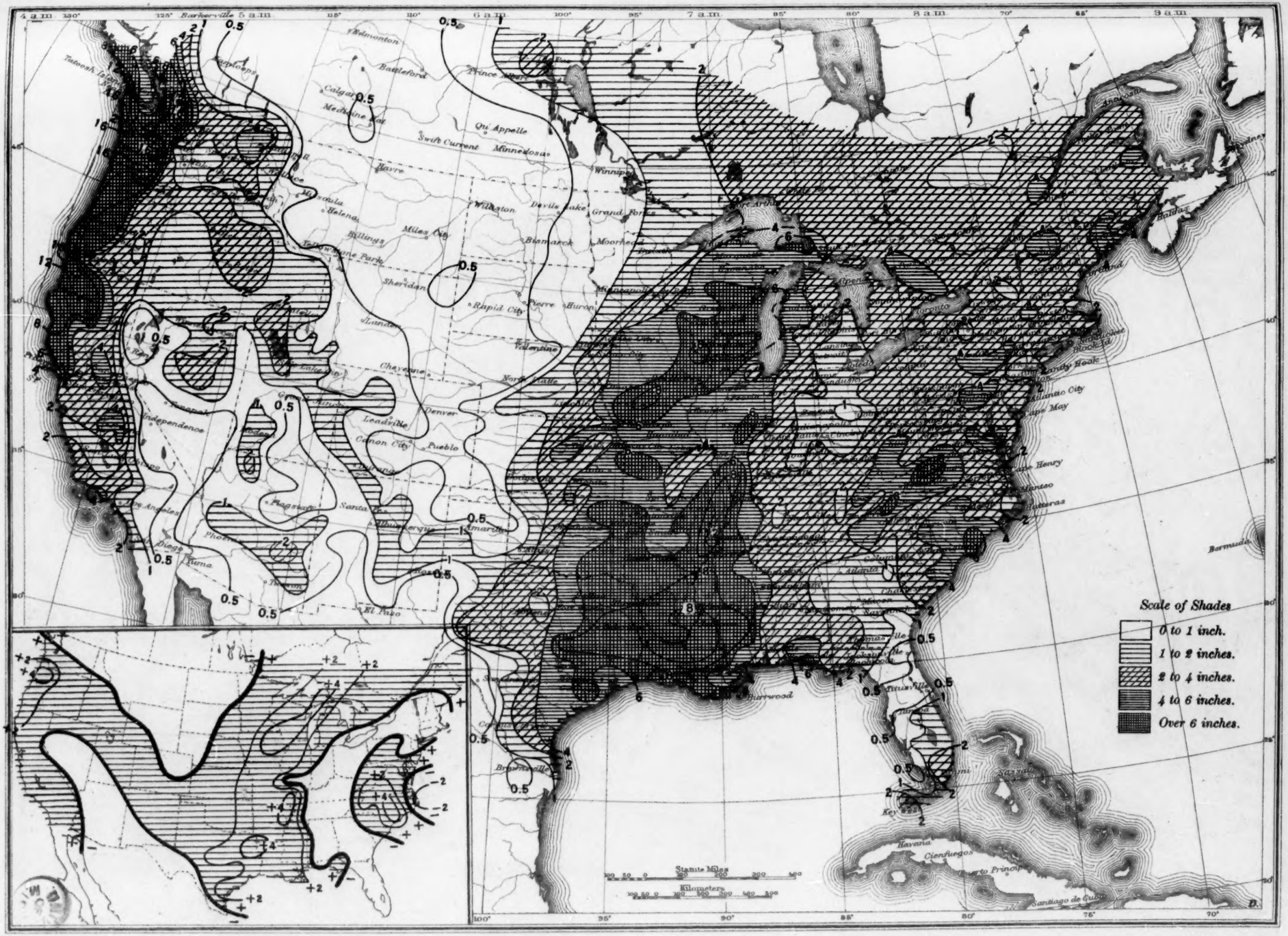


Chart VI. Isobars at Sea Level and Isotherms at Surface; Prevailing Winds, November 1934

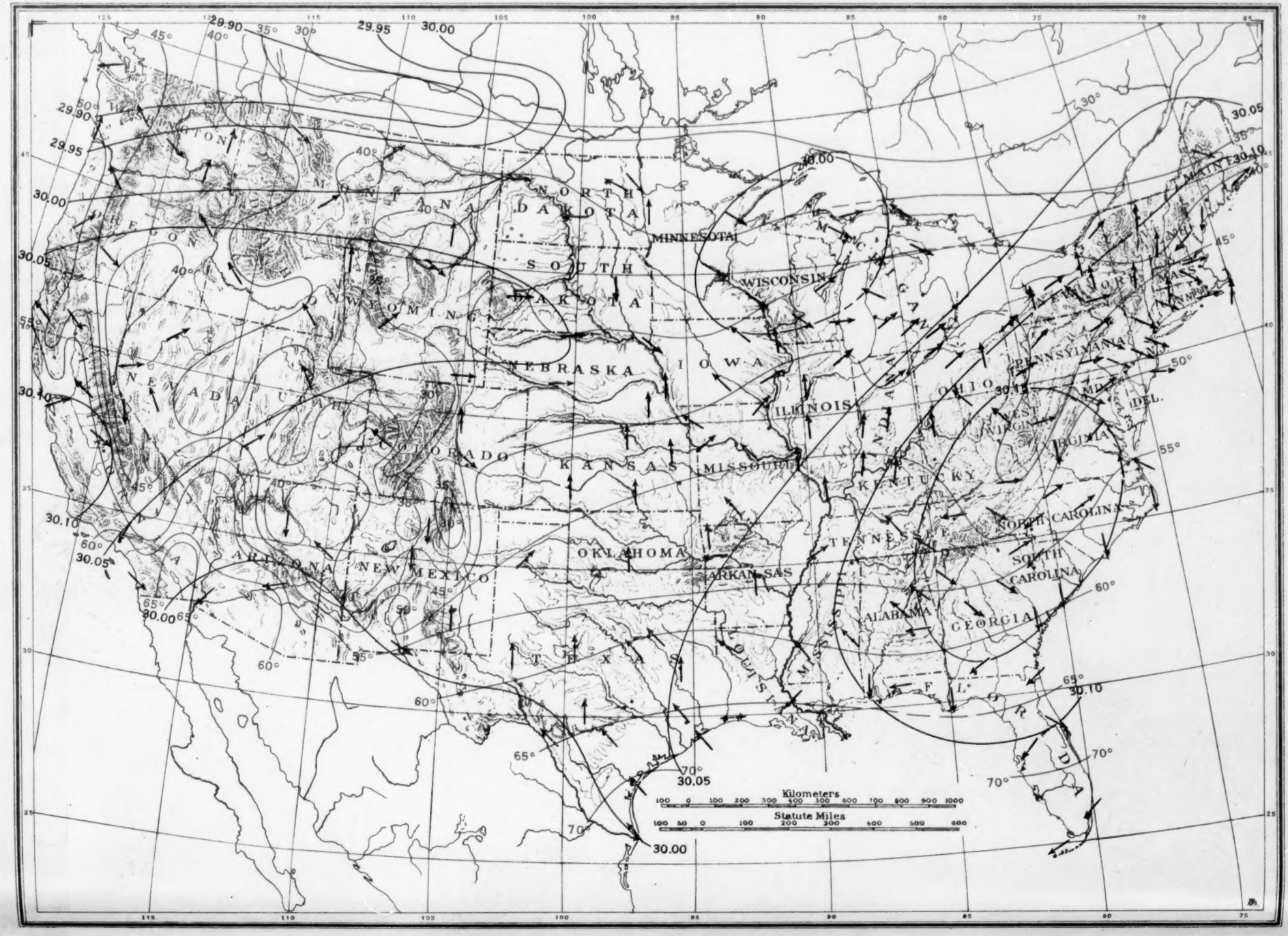


Chart VII. Total Snowfall, Inches, November 1934

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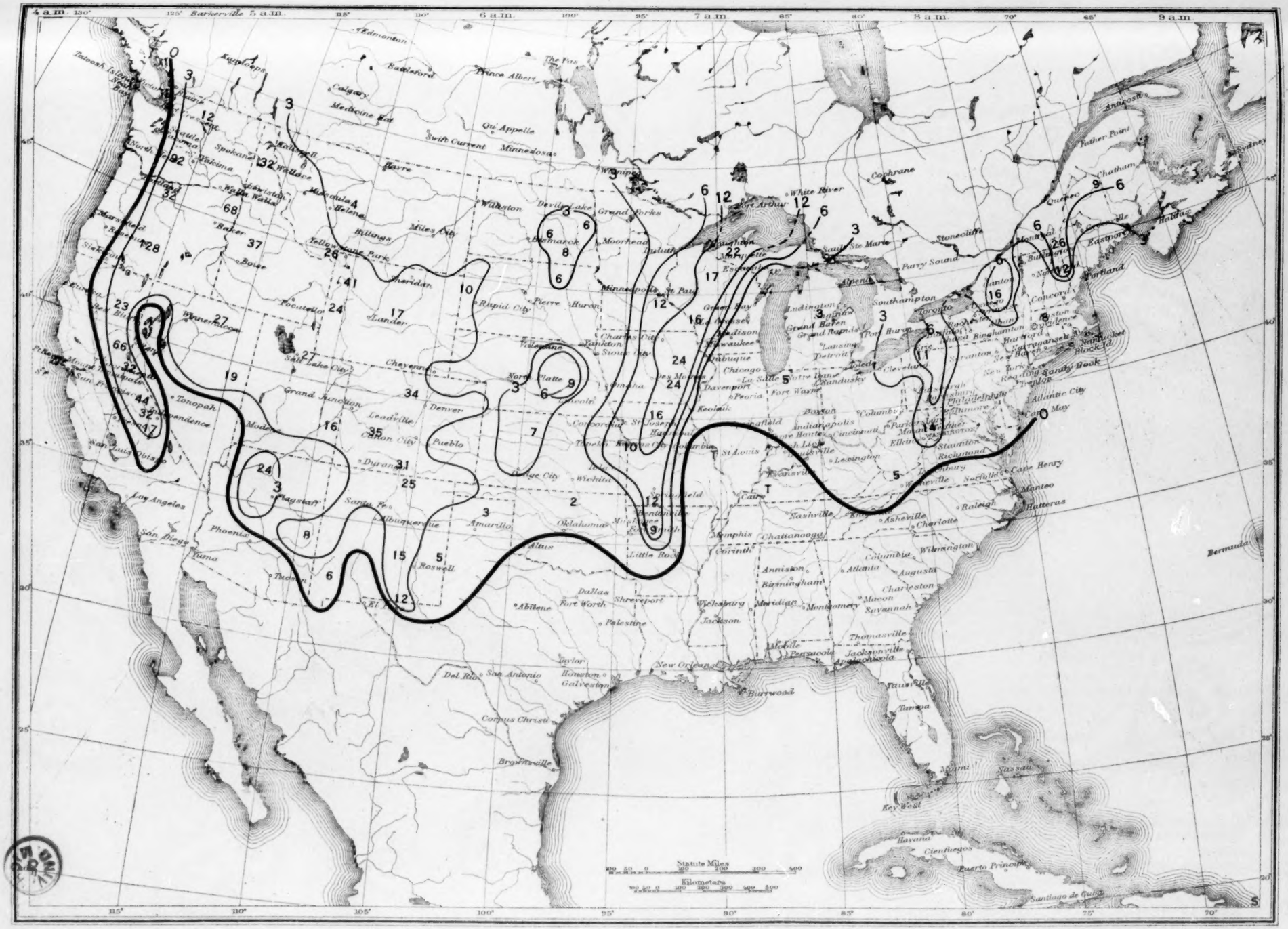

Chart VIII. Weather Map of North Atlantic Ocean, November 15, 1934
(Plotted from the Weather Bureau Northern Hemisphere Chart)

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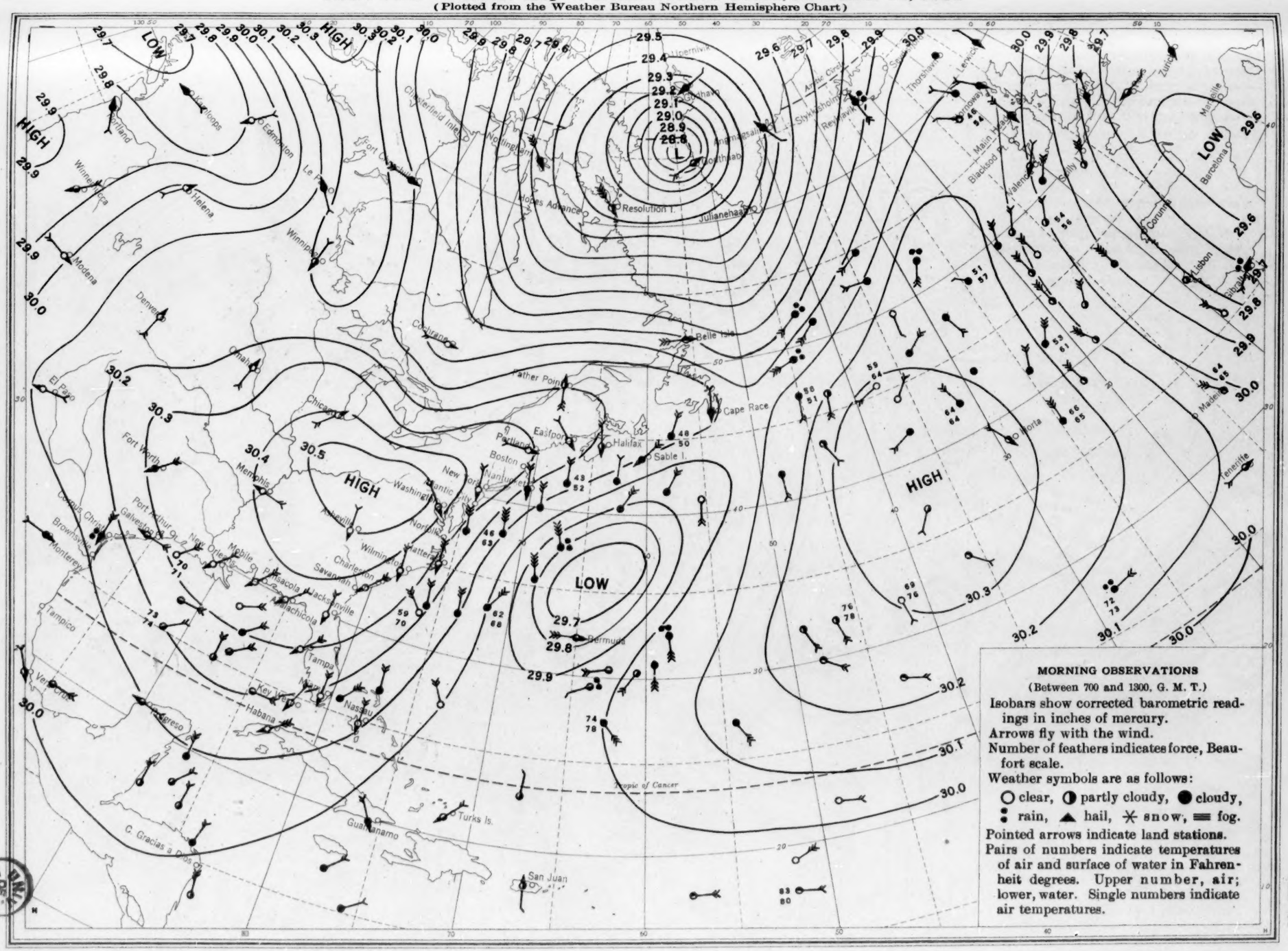
(Plotted from the Weather Bureau Northern Hemisphere Chart)



MORNING OBSERVATIONS
(Between 700 and 1300, G. M. T.)

Isobars show corrected barometric readings in inches of mercury.

Arrows fly with the wind.

Number of feathers indicates force, Beaufort scale.

Weather symbols are as follows:

○ clear, ◑ partly cloudy, ● cloudy, ⁝ rain, ▲ hail, ✳ snow, ═ fog.

Pointed arrows indicate land stations.

Pairs of numbers indicate temperatures of air and surface of water in Fahrenheit degrees. Upper number, air; lower, water. Single numbers indicate air temperatures.

Chart IX. Weather Map of North Atlantic Ocean, November 16, 1934

(Plotted from the Weather Bureau Northern Hemisphere Chart)

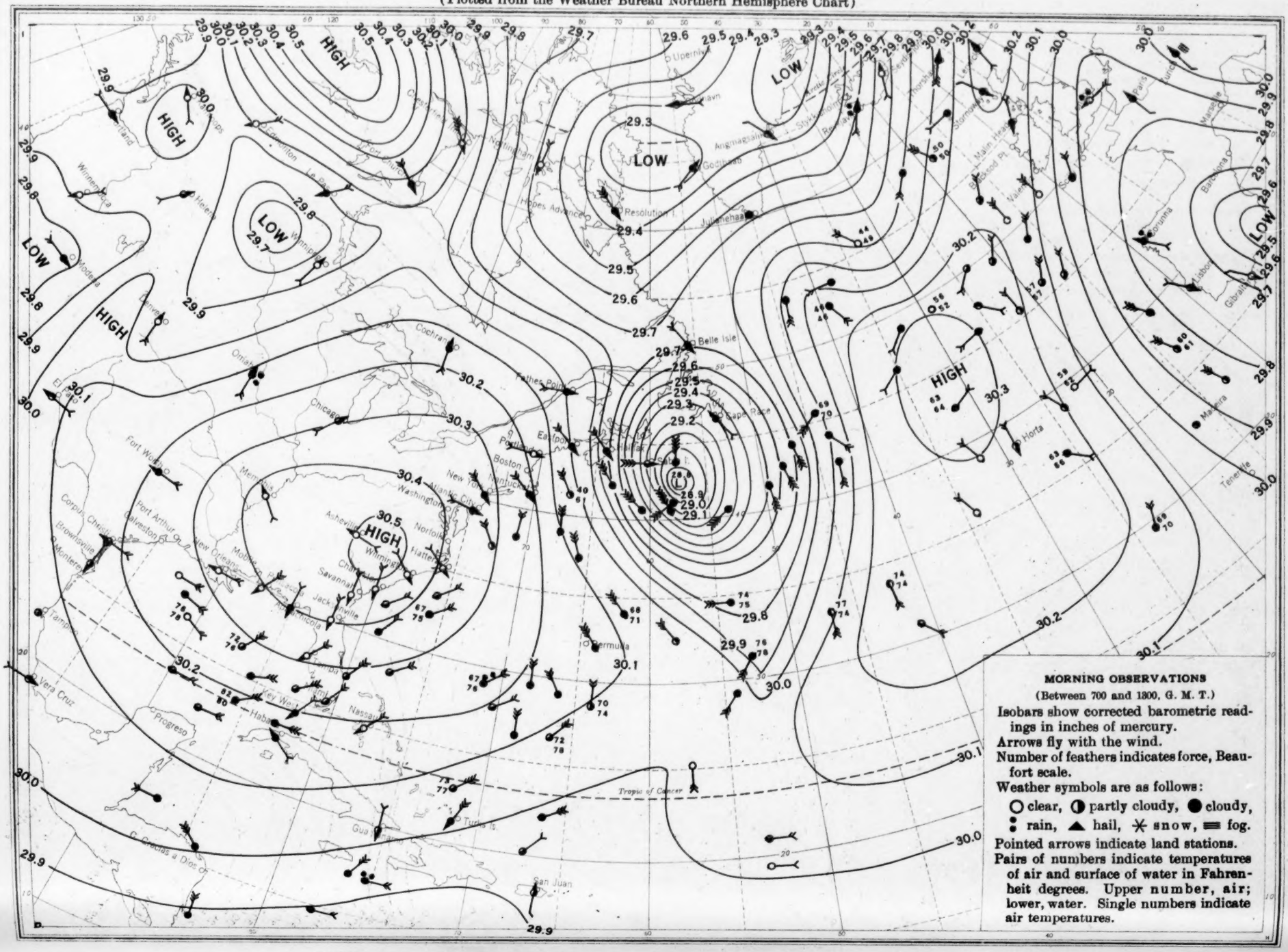
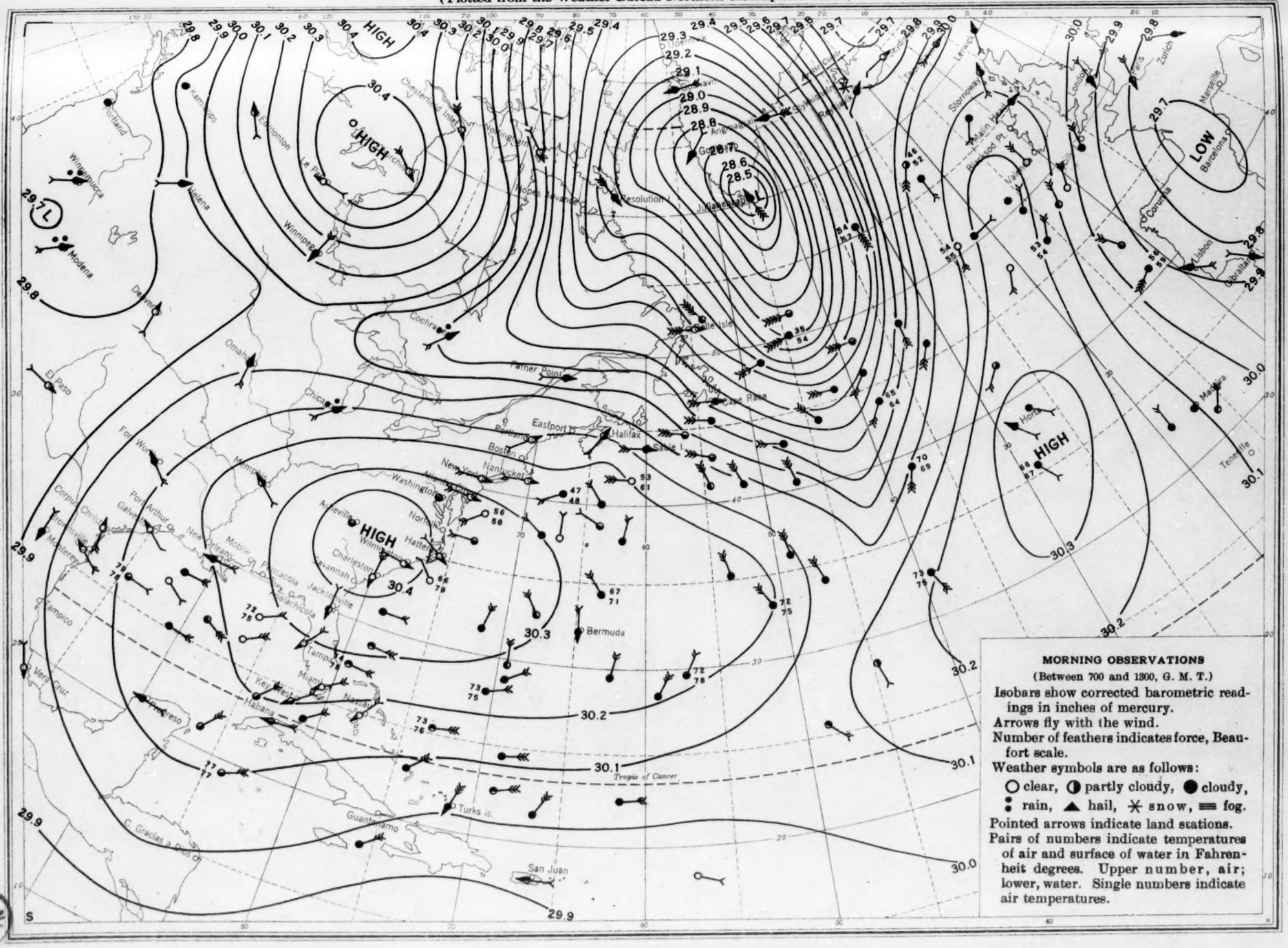

HIGH
LOW
Belle Isle
Bermuda
Tropic of Cancer
MORNING OBSERVATIONS
(Between 700 and 1300, G. M. T.)
Isobars show corrected barometric readings in inches of mercury.
Arrows fly with the wind.
Number of feathers indicates force, Beaufort scale.
Weather symbols are as follows:
clear, partly cloudy, cloudy,
rain, hail, snow, fog.
Pointed arrows indicate land stations.
Pairs of numbers indicate temperatures of air and surface of water in Fahrenheit degrees. Upper number, air; lower, water. Single numbers indicate air temperatures.

Chart X. Weather Map of North Atlantic Ocean, November 17, 1934

(Plotted from the Weather Bureau Northern Hemisphere Chart)

Chart X. Weather Map of North Atlantic Ocean, November 17, 1934
(Plotted from the Weather Bureau Northern Hemisphere Chart)


HIGH
HIGH
HIGH
HIGH
LOW
Barcelona
Bermuda
Tropic of Cancer
MORNING OBSERVATIONS
(Between 700 and 1300, G. M. T.)
Isobars show corrected barometric readings in inches of mercury.
Arrows fly with the wind.
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Weather symbols are as follows:
clear, partly cloudy, cloudy,
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